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P.V. 775244
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Vol. III

TRANSCRIPT OF RECORD

Supreme Court of the United States

OCTOBER TERM, [redacted] 1938

No. [redacted] 1

GENERAL TALKING PICTURES CORPORATION,
PETITIONER,

vs.

WESTERN ELECTRIC COMPANY, INC., ELECTRICAL RESEARCH PRODUCTS, ET AL.

ON WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE SECOND CIRCUIT

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INDEX.

(Equity No. 50-175)

(Equity No. 50-177)

(Equity No. 50-178)

PLAINTIFFS' WITNESSES.

DEFENDANT'S WITNESSES.

SUB-REBUTTAL PROOFS.

Plaintiffs' Exhibits.

DEFENDANT'S EXHIBITS.

Patent No.	Patentee	Issue Date	Offd. Page	Ptf. Page
1,340,101	Alexanderson	May 11, 1920		1502
1,350,752	Van der Bijl	Aug. 24, 1920		1507
1,375,447	DeForest	Apr. 19, 1921		1514
1,377,405	DeForest	May 10, 1921		1523
1,384,108	Weagant	July 12, 1921		1528
1,388,450	Colpitts, *et al.*	Aug. 23, 1921		1531
1,393,369	Hewitt	Oct. 11, 1921		1537
1,398,665	Arnold	Nov. 29, 1921		1541
1,432,863	Johnson	Oct. 24, 1922		1546
1,448,550	Arnold	Mar. 13, 1923		640
1,558,436	Langmuir	Oct. 20, 1925		1550

3913

Defendant's Exhibit A.

GENERAL ELECTRIC-RADIO MAIN AGREEMENT

AGREEMENT made this 20th day of November, 1919, between GENERAL ELECTRIC COMPANY, a New York corporation, hereinafter called the General Company, and RADIO CORPORATION OF AMERICA, a Delaware corporation, hereafter referred to as the Radio Corporation.

3914

RECITALS.

A. The General Company has developed various inventions relating to, or applicable to, radio work and other communication work.

B. The General Company is under obligation to certain foreign companies to give them for their territory respectively exclusive rights to its various inventions and discoveries and to the business of selling General Electric products. 3915 Some of these companies are substantially controlled by the International General Electric Company, a New York corporation, hereinafter referred to as the International Company.

C. The Radio Corporation proposes to establish, maintain and operate radio stations, and cable and wire lines and stations, and to deal in, lease and maintain radio devices, and desires to utilize in such work the various inventions now controlled by the General Company and which may hereafter be controlled by it.

ARTICLE I.

Definitions.

1. Radio purposes is defined as the transmission or reception of communications, telegraphic, telephonic, or other, by what are known as electromagnetic waves, but not by wire.

2. Radio devices are defined as comprising:

3917 (*a*) Devices useful only in radio purposes.

(*b*) Devices especially adapted to radio purposes but capable of other uses, such, for example, as the Alexanderson alternator with accessories or the pliotron, except where the same are sold licensed only for uses other than radio uses in which case the same are not to be regarded as radio devices hereunder.

3. The expression "devices" shall include ap-
3918 paratus, devices, systems, connections and methods.

ARTICLE II.

Licenses.

1. Reserving to itself and its controlled companies, present and future, respectively, personal licenses, transferable only to the successors to their business, or part thereof, and divisible only as their business is divided, to use for their own communication or other purposes for the convenience or to save expense, but not for

profit, the General Company hereby grants to the Radio Corporation an exclusive divisible license to use and sell as well as a non-exclusive indivisible license to make only when, and to the extent that, the General Company is not in a position to supply the desired device with reasonable business promptness (the right to use and sell being limited to the use and sale of apparatus purchased from the General Company or with its written consent, so far as the General Company is from time to time in condition to 3920
supply the same with reasonable business promptness) for radio purposes under all patents, applications for patents, inventions and rights or licenses under or in connection with patents which the General Company now owns or controls, or which it may acquire during the term hereof except those acquired by purchase and referred to below.

2. The General Company also grants to the Radio Corporation a non-exclusive non-transferable license to use, but not to make or sell 3921
(with the same limitations) for wire communication purposes under all patents, applications, inventions, rights and licenses which it now owns or controls or which it may acquire during the term hereof by inventions of its employees.

3. For the purposes hereof the inventions, patents and rights of the General Company are taken as including those of the International Company as well as following corporations, namely:

Australian General Electric Company;

China General Edison Company, Inc.,
Compania General Electric do Brazil,
South African General Electric Company, Ltd.,
Cia General Electric Sudamericana, Inc.,
Mexican General Electric Company.

4. The Radio Corporation grants to the General Company the exclusive, divisible right to make and sell radio devices to the Radio Corporation only as well as the exclusive divisible
3923 right to make, use and sell devices other than radio devices, under all its patents and applications for patents, inventions and rights or licenses under or in connection with patents which the Radio Corporation now owns or controls, or which it may acquire during the term hereof except as far as is provided below in the case of certain such acquired by purchase. The Radio Corporation grants the General Company and its controlled companies, present and future, non-exclusive licenses transferable only to successors to their business or parts thereof, di-
3924 visible only as their business is divided, to use for their own communication or other purposes for convenience or to save expense but not for profit under all the patents which the Radio Corporation now owns or controls or which it may acquire during the term hereof from the General Company or by inventions of its own employees or through contracts which it now has.

5. The said licenses are all to run for the terms for which the patents are or may be granted, re-issued or extended; and are subject to royalty only in so far as such royalties are payable to others by virtue of the contracts by

which the party granting the licenses acquired or shall acquire the right to grant the same, and only at a rate not greater than that paid by such party.

6. Where in any case a party does not own or control a patent but has lawful power to grant rights or licenses thereunder to the other for part or all of its field or territory it shall do so subject to the conditions hereof.

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7. In case the General Company shall acquire by purchase from others patents, patent applications, or rights or licenses under or in connection with patents, useful for or applicable to radio purposes or wire communication, and in case the Radio Corporation similarly acquires such patents, patent applications, or rights or licenses, the party making the acquisition will offer to the other to bring the same within the scope of this contract on payment of a fair proportion of the price actually paid or to be
paid therefor. This shall not apply in the case 3927
of any patent, patent application, right or license secured by the Radio Corporation from or through the Marconi Wireless Telegraph Company of America, Marconi's Wireless Company, Limited, Compagnie Generale de Telegraphie sans Fils, or others with whom the Radio Corporation may have relations similar to its actual or proposed relations with any of said companies; all such are to be treated as though they were not acquired by purchase.

8. The General Company has sold its inventions for certain countries to companies other

3928

than those mentioned in Section 3 of this article. All covenants of the General Company with respect to such countries are subject to the present rights of the companies holding such inventions. As such rights revert to the General Company they shall pass under the operation of this contract without further consideration.

9. Each company agrees to continue the present practice of the General Company of requir-
3929 ing those employees considered likely to make inventions along this line of work to assign inventions to it; it being understood that each company shall use its best efforts to carry out this provision, but if due care and diligence are exercised neither company shall be liable in damages for failure to carry it out.

10. As soon as is reasonably possible after the filing by or on behalf of a party hereto of a United States patent application, rights to or under which should pass to the other party, the
3930 party filing the application shall transmit a copy thereof to the other party with a statement of its filing date and shall notify the other party of the countries foreign to the United States in which it has decided to file and will file applications to cover the invention of such application. The other party may then suggest that applications should be filed in additional foreign countries in which the first party has the right to file. If and so far as the first party does not within thirty (30) days after such suggestion agree to file in such other foreign countries the other party may file proper applications for protecting such invention in such other for-

eign countries, and take patents thereon in its own name at its own expense. Before either party intentionally drops an application or patent of any country, rights to or under which should pass to the other hereunder, it shall notify the other party in which case such other party may continue the prosecution of the application or continue the life of the patent in question at its own expense, being entitled in such case to an assignment thereof.

11. In case a right, application or patent is 3932
transferred by one party to the other in accordance with the provisions of Section 10 of this article, the party with which such right, application or patent organized shall be entitled to its full rights thereunder as though such patent had originated with and had been taken out by the other party subject to any royalty or other payment required to be made to an outsider in accordance with this agreement.

12. The admission of validity implied in the 3933
acceptance of licenses and assignments hereunder is limited to the field and terms for which such licenses exist.

13. The General Company empowers the Radio Corporation to release the United States Government from any and all claims arising from past infringement by the Government of any radio patents which the General Company now owns or under which it has power to grant such release, provided that this can be done in a contract otherwise satisfactory to the General Company.

ARTICLE III.

Restrictions on Sales of Apparatus.

1. The General Company agrees that it will not sell or dispose of any radio devices whatever covered by patents, rights under which are granted or agreed to be granted herein, for use in the United States except to fill orders now on hand, and except to the United States Gov-
3935 ernment in cases where the Government insists on purchasing directly from the General Company (in which case the profits from such sales over the price of such devices to the Radio Corporation hereunder shall be paid to the Radio Corporation). The General Company further agrees that it will not sell or dispose of for use outside the United States any radio devices whatever covered by patents, rights under which are granted or agreed to be granted herein, except as it may be required to do so by existing contracts with others than the companies spe-
3936 cifically named in Section 3 of Article II hereof and except for its own use or for the use of the Radio Corporation. This reservation is not intended to enlarge the scope of the licenses granted in Article II hereof.

ARTICLE IV.

Sale of Apparatus.

1. The Radio Corporation agrees to purchase from the General Company all radio devices covered by patents, rights under which are granted or agreed to be granted herein, which

the General Company is from time to time in a position to supply with reasonable business promptness for use in, or which are used in, the business and operation of the Radio Corporation and its licensees and customers.

2. The General Company agrees to produce or cause to be produced such patented devices of good quality, workmanship, and material with reasonable business promptness on the written order of the Radio Corporation. 3938

3. The basis for determining the price charged by the General Company to the Radio Corporation shall be cost plus 20%, except that for all articles complete in themselves which are purchased by the General Company from outside manufacturers and which form a necessary part of the complete device supplied by the General Company, the price charged by the General Company to the Radio Corporation shall be cost plus 10% for handling charges.

3939

4. The basis for determining cost shall be in accordance with the "Standard Accounting and Cost System for the Electrical Manufacturing Industry," as approved by the Federal Trade Commission, January 27, 1917.

5. Terms of payment shall conform to the standard terms of the General Company current at the time of placing the order.

6. If the Radio Corporation in any particular instance wishes the General Company to make a definite and firm price for such radio devices,

and the General Company consents to make such firm price, such firm price upon acceptance by the Radio Corporation shall be substituted in such instance or instances for the cost plus 20% arrangement above mentioned.

7. All prices mentioned above shall be f. o. b. factory.

8. Standard material not specially designed for radio purposes is to be sold to the Radio
3941 Corporation at standard prices and on standard terms of payment but at the lowest price at which such standard material is sold in like quantities to any other customer of the General Company for use in the United States of America; and if at any time material, apparatus or supplies especially designed for radio purposes shall be sold by the General Company to its other customers for other uses than radio purposes in an amount greater than that taken by the Radio Corporation, the price at which such material, apparatus or supplies shall be
3942 sold to the Radio Corporation shall be the lowest price at which such material, apparatus or supplies are sold in like quantities to any other customer of the General Company for use in the United States of America. In determining such lowest price under this Section 8 no account shall be taken of sales:

(1) To those corporations in which the General Company may own a substantial amount of stock;

(2) Where the General Company sells material on a schedule, such material is to be billed to the Radio Corporation according to such schedule;

(3) Where the General Company has a lawful contract not to sell material below a certain price, such material is not to be billed to the Radio Corporation for a less price:

(4) To the United States Government or any of its departments.

9. It is agreed that the Radio Corporation
shall not resell patented articles except as a part
of the radio system. 3944

10. The Radio Corporation agrees not to
lease, sell or dispose of devices bought of the
General Company, where the General Company
or one of the companies mentioned in Section 3
of Article II hereof would not be free to sell
such devices. It being understood that the rights
of the Radio Corporation are only for radio
purposes as above defined, the Radio Corporation agrees to use care not to enter with any
patented device, process or system into the field
of the General Company or to encourage or aid 3945
others to do so, and specifically that in selling
radio devices it will use such precautions by
contract of sale, restricted license notices, etc.,
as may be necessary or advisable to prevent its
customers from acquiring (by purchase from it
of devices or otherwise) licenses to use the same
for purposes of which the Radio Corporation
has no right to grant such licenses. The General
Company agrees to observe similar precautions
in selling apparatus and devices especially
adapted to radio work but capable of other uses.

11. The General Company agrees to sell the Radio Corporation such patented communication

devices as it may be in position to supply other than radio devices on the same terms, but only for the use of the Radio Corporation and not for resale or lease or other disposal and not exclusively.

ARTICLE V.

Alexanderson Alternator.

1. The Radio Corporation agrees to purchase
3947 from the General Company and the General Company agrees to sell and deliver f. o. b. factory to it, as fast as they can reasonably be constructed and prior to January 1, 1922, twelve (12) Alexanderson alternators complete with accessories, in accordance with specifications attached hereto and marked "Exhibit B" at the special price of one hundred twenty-seven thousand dollars ($127,000) apiece. Spare alternators or other incomplete spare equipments may be substituted at prices to be agreed upon provided that the total purchases hereunder aggregate in
3948 price the price of the twelve Alexanderson alternators with their accessories. In consideration for such agreement on the part of the General Company, the Radio Corporation agrees to issue and deliver to the General Company three hundred four thousand eight hundred (304,800) shares of its preferred stock, but subject to the provisions of Article VI hereof.

ARTICLE VI.

Sale of Materials.

1. The Radio Corporation proposes to purchase from the Marconi Wireless Telegraph

 3949

Company of America, hereinafter referred to as the Marconi Company, all of its property used or useful in connection with its manufacturing business, except the factory at Aldene, New Jersey. In case this purchase is made the Radio Corporation agrees forthwith to sell and does sell the property so purchased to the General Company, such sale to take effect immediately on the purchase of the same by the Radio Corporation, including all drawings, blueprints and
material for manufacture and unfinished parts 3950
on hand or on order as of the date of the Radio Corporation's acquisition of the same, and any factory plants, tools, machinery and dies which it may acquire from the Marconi Company, but not including the publishing plant of the Wireless Press, Inc., nor the building and real estate at Seattle, Washington, which latter will no longer be used for factory purposes. The accounts receivable are to be collected and the accounts payable are to be paid by the Radio Corporation.

3951

2. The General Company agrees to pay for the property thus transferred by paying for the unfinished parts, work in progress and material on hand to be manufactured at actual cost of the same plus twenty per cent. (20%), which amount is to be ascertained by two appraisers, one appointed by the General Company and one appointed by Mr. Edward J. Nally. In case they disagree the matter shall be referred to Mr. S. Roger Mitchell, or other public accountant satisfactory to both parties, whose decision shall be final.

3952 *Defendant's Exhibit A.*

3. In case the Radio Corporation shall acquire, prior to January 1, 1922, the factory plants, lands, etc., of the Marconi Company, at Aldene, New Jersey, as set forth in Exhibit C hereto attached, it agrees forthwith to sell the same to the General Company and the General Company agrees to buy the same for five hundred thousand dollars ($500,000).

4. The payments by the General Company to
3953 the Radio Corporation under this Article and deliveries of preferred stock to the General Company in payment for Alexanderson alternators and their accessories in accordance with Article V hereof, are to proceed as follows: At the time of taking over the unfinished parts, work in progress and material on hand, a special account is to be set up between the General Company and the Radio Corporation, in which account is to be charged against the General Company the value of such unfinished parts, work in progress and material on hand, ascertained as above; if
3954 and when, prior to January 1, 1922, the Radio Corporation acquires the Aldene factory and transfers it to the General Company, its price five hundred thousand dollars ($500,000) is to be charged in the same account against the General Company. As and when the Alexanderson alternators and their accessories sold at the special price referred to above are shipped to the Radio Corporation, the price thereof is to be credited to the General Company on such account, until such credits aggregate one million five hundred twenty-four thousand dollars ($1,524,000). At any time when such account shows a balance in favor of the General Company the General Com-

pany may demand and shall then receive preferred stock of the Radio Corporation at par to any amount demanded not exceeding such credit balance, the par value of such stock to be charged to it in such special account and if at any time the balance of said account is in favor of the Radio Corporation, the General Company shall liquidate such balance by surrender to the Radio Corporation of preferred stock of the Radio Corporation of a par value equal to the amount
of such balance. Such special account shall be 3956
entirely independent of all other accounts between the parties.

5. The Radio Corporation agrees to place forthwith with the General Company orders which will exhaust and consume said unfinished parts, work in progress and material; unfinished parts, work in progress and material not covered by such orders may be regarded by the appraisers as scrap in case the General Company shall find itself unable profitably to utilize
the same. 3957

6. The General Company agrees to fill the orders so to be placed on it and to bill the same to the Radio Corporation; in making up price of the articles so billed in accordance with Article IV hereof, the price of the unfinished parts, work in progress and material taken over and inventories shall be taken as the price actually paid for the same by the General Company as above set forth, the additional work and material being charged on the basis of Article IV hereof.

ARTICLE VII.

Expert Advice and Technical Information.

1. The General Company agrees that it will from time to time permit the Radio Corporation to have and will assist it in obtaining full information concerning inventions, patents and the patent situation of the General Company in the radio field. The Radio Corporation engages reciprocally to do the same for the General Company.

3959

2. The General Company agrees upon request to furnish the Radio Corporation suitable plants for buildings lay-out of machinery, antennae, etc., for use by the Radio Corporation hereunder, and if desired a man or men to supervise the construction and erection of such buildings, and the erection and installation of such machinery, etc., and also such other engineers and experienced men as the General Company can reasonably spare and the Radio Corporation may reasonably require in the organization,
3960 management and development of the business of the Radio Corporation, and to give the Radio Corporation and those whom the Radio Corporation may designate from time to time all information in regard to technical and engineering but not manufacturing matters which it may possess from time to time and which the Radio Corporation may reasonably require for the conduct of its radio business hereunder, and further agrees to assist the Radio Corporation in every reasonable way to the end that the Radio Corporation shall have whenever needed, in its operations hereunder, the benefits of the widespread experience of the General Company.

The Radio Corporation agrees to pay in each case the reasonable cost of furnishing such information and service, but not any part of the cost of acquiring the information except as the same may properly be charged as part of the development cost of apparatus which the General Company sells to the Radio Corporation.

3. Each party agrees to give the other at cost of supplying the same information and advice in connection with patent matters in its field.

4. The Radio Corporation agrees to give full information to the General Company on the same terms, and further agrees to afford the engineering representatives of the General Company the fullest possible facilities, consistent with the reasonable operation of the Radio Corporation, for experimenting and for developing and testing new apparatus, devices and inventions. 3962

ARTICLE VIII.

Term and Termination. 3963

1. This agreement shall continue until January 1, 1945, at which date it shall expire. As soon as is reasonably practicable after that licenses shall be granted as provided above under all patents to issue on patent applications which are then or may hereafter be filed in any country on inventions made or conceived by employees of either company up to the date of termination.

2. The Radio Corporation shall after January 1, 1945, be licensed under all patents referred to in this agreement so far as the General Company now has or may hereafter acquire the right to grant such license to the extent neces-

3964 sary to enable it to manufacture for its own use hereunder, but not for lease, resale or other disposal, radio devices which it is unable to purchase of the General Company in accordance with the terms of Article IV hereof.

ARTICLE IX.

Further Assurances.

1. The parties agree to execute such further
3965 instruments as may reasonably be necessary for carrying out the purposes hereof.

ARTICLE X.

Controlled Companies.

1. This agreement shall be binding upon and inure to the benefit of the parties hereto and their successors and their controlled companies, present and future. The British Thomson-Houston Company, Limited and the Tokyo Electric Company, Limited, shall not for the purposes
3966 hereof be regarded as controlled companies of the General Company.

ARTICLE XI.

1. Inasmuch as the General Company is not willing to turn over its patents, patent rights and licenses for any definite sum of money, but is willing to transfer such patents, patent rights and licenses only for a considerable interest in the profits to be derived from the use by the Radio Corporation of such patents, patent rights and licenses, it is therefore understood and agreed that in the event of the taking over of the Radio Corporation by any superior authority all right, title and interest of the Radio Cor-

poration in any patent, patent right or license herein granted or agreed to be granted by the General Company to the Radio Corporation shall cease and shall be reassigned and shall revert to the General Company as of the date of such taking over except to the extent provided below. If instead of taking over the Radio Corporation the Government takes over its radio stations in any field and/or territory, except in and for time of war or public danger, the same result
shall follow so far as concerns that field and/or 3968
territory. But this action shall in no way affect the rights of Marconi's Wireless Telegraph Company, Limited, or of Shielton, Limited, as set forth in the "Radio Corporation and British Marconi Company Principal Agreement", such rights shall be reserved from any such reassignment by the Radio Corporation for the benefit of Marconi's Wireless Telegraph Company.

IN TESTIMONY WHEREOF the parties hereto have caused these presents to be executed and their corporate seals to be hereunto affixed by their
proper officers thereunto duly authorized at New 3969
York City the day and year first above written.

GENERAL ELECTRIC COMPANY,
By E. W. RICE, JR.,
President.

Attest:

J. W. ELWOOD,
Assistant Secretary.

RADIO CORPORATION OF AMERICA,
By FREDERICK C. BATES,
President.

Attest:

CHARLES H. WHEELER,
Secretary.

STATE OF NEW YORK, }
COUNTY OF NEW YORK, } ss.:

On this twentieth day of November, in the year one thousand nine hundred and nineteen, before me personally came Frederick C. Bates, to me known, who being by me duly sworn, did depose and say that he resides at Brooklyn, New York, that he is the President of the Radio Corporation of America, the corporation de-
3971 scribed in and which executed the above instrument, and also before me personally came Charles J. Wheeler, to me known, who, being by me duly sworn, did depose and say that he resides at Montclair, New Jersey; that he is the Secretary of the Radio Corporation of America, the corporation described in and which executed the above instrument; that he knows the seal of the said corporation; that the seal affixed to the said instrument is such corporate seal; that it was so affixed by order of the board of directors of the said corporation, and both the said
3972 Bates and the said Wheeler did depose and say that they had signed their names to the said instrument by order of the board of directors of the said corporation.

GERTRUDE CHANDLER,
Notary Public,
New York County No. 386,
New York County Register's No. 10324,
Commission Expires March 30, 1920.

STATE OF NEW YORK, }
COUNTY OF NEW YORK, } ss.:

On this twentieth day of November, in the year one thousand nine hundred and nineteen, before me personally came E. W. Rice, Jr., to me known, who, being by me duly sworn, did depose and say that he resides at Schenectady, New York; that he is the President of the General Electric Company, the corporation described in and which executed the above instrument, and 3974
also before me personally came J. W. Elwood, to me known, who, being by me duly sworn, did depose and say that he resides at Van Hornesville, New York; that he is the Assistant Secretary of the General Electric Company, the corporation described in and which executed the above instrument; that he knows the seal of the said corporation; that the seal affixed to the said instrument is such corporate seal; that it was so affixed by order of the board of directors of the said corporation, and both the said Rice and the said Elwood did depose and say that 3975
they had signed their names to the said instrument by order of the board of directors of the said corporation.

GERTRUDE CHANDLER,
Notary Public,
New York County No. 386,
New York Register's No. 10324,
Commission Expires March 30, 1920.

3976

EXHIBIT B.

Item 1: 1-High frequency motor generator set consisting of:
1-600 H.P., 8-pole, quarter-phase, 2,200 volt, 900 r.pm. induction motor direct connected through a 3:1 gear to an alternator capable of generating directly frequencies up to 27,000 cycles.

Item 2: 1-High frequency transformer adapting
3977 the voltage of the alternator for the antenna.

Item 3: 1-Speed regulator for maintaining constant speed corresponding to wave lengths between 11,500 and 15,000 metres.

Item 4: 1-Magnetic amplifier for controlling the output of the alternator.

Item 5: 1-Switchboard for controlling the operation of driving motor and auxiliaries.

Item 6: 1-Operator's control board to control operation of the high frequency circuits.

Item 7: 1-Set of multiple tuning accessories for the antenna, equal in number to those now
3978 installed at New Brunswick, N. J.

Item 8: 1-3 Unit motor generator set consisting of a 440 volt, 3 phase induction motor, direct connected to a 15 Kw. 125-250 volt D. C. generator.

Item 9: 2-Motor driven water pumps providing circulating water for alternator bearings and armature.

Item 10: Full set of instructions and drawings suitable for installation and operation purposes.

The Company proposes to furnish apparatus and devices for a complete, continuous-wave

radio transmitting system for hand key operation, exclusive of building, foundations, towers for antenna, water and power supply.

The items enumerated above constitute the principal features of this system.

Multiple tuning of the antenna increases the efficiency of radiation. The Company's guarantee as to operation is based on this fact and the use of the multiple tuned antenna. Item No. 7 covers apparatus that will be used to accom-
plish multiple tuning. The equipment may be 3980
used without multiple tuning, but when so used the efficiency of the system will be decreased.

The motor and gear are designed for a maximum speed corresponding to a wave length of 11,500 metres and variable speed control is provided for operation at longer waves. The system to be furnished is designed to operate at wave lengths between 11,500 metres and 15,000 metres and is guaranteed, when used with multiple tuned antenna, to produce a charging current of 400 amperes at 12,000 metres in an an-
tenna of the New Brunswick, New Jersey, type. 3981
The antenna charging current is to be measured when the key is pressed and the equipment shall be capable of operating continuously for a period of twenty-four consecutive hours with telegraph control.

Exhibit C.

The land and real estate now owned by the Marconi Company at Aldene, in the State of New Jersey, together with the factory buildings, wireless towers and structures located on such land, the said land being located between the

fork of the Lehigh Valley Railroad and the Central Railroad of New Jersey on the east and bounded on the north by Westfield Avenue, together with the tools and machines in all such structures.

Defendant's Exhibit B.

3983 LICENSE AGREEMENT

GENERAL ELECTRIC COMPANY

AND

AMERICAN TELEPHONE AND TELEGRAPH COMPANY.

July 1, 1920

AGREEMENT made this first day of July, 1920, between the GENERAL ELECTRIC COMPANY, a New York corporation (herein called the General
3984 Company), and the AMERICAN TELEPHONE & TELEGRAPH COMPANY, a New York corporation, herein called the Telephone Company

WHEREAS, the General Company is engaged in the manufacture and sale in the United States of apparatus and systems for the generation, distribution and utilization of electricity for light, heat, power, traction and associated purposes, and in the manufacture and sale of a general line of electrical and power apparatus, machines and appliances, and, directly and through affiliated companies, is engaged in the purchase of apparatus and devices of various kinds from

others and in the sale thereof; and is also engaged in the manufacture and sale of wireless apparatus and appliances; and

WHEREAS, the Telephone Company and its Associated Companies are engaged in the operation of telephone and telegraph systems; and

WHEREAS, each party is in possession of information, patents and inventions applicable to, and has research organizations engaged in investigations bearing upon, not only its own business but also the business of the other party; and 3986

WHEREAS, various patents or applications for patents of the parties are involved in interference with each other in the United States Patent Office; and

WHEREAS, the restrictions upon each party imposed by the patent rights of the other and the uncertainties arising out of interferences have tended to, and if permitted to continue will, hamper and delay progress in the development and production of wire and wireless telephone and telegraph apparatus and systems; and 3987

WHEREAS, the effective and prompt development of the arts in question can be secured only by the free and frank cooperation and exchange of information between the parties, which cannot well take place if improvements and knowledge resulting from one party's cooperation with the other party, may without its consent be made available in its field to the use of others.

3988 Now, in consideration of the premises and the mutual agreements herein continued, it is agreed as follows:

ARTICLE I.

Definitions.

For the purposes of this agreement the following terms are defined as follows:

3989 "Wire Telephony" is the art of communicating on reproducing sound waves (created, directly or indirectly, by the voice or by musical instruments) by means of electricity, magnetism or electro-magnetic waves, variations or impulses conveyed or guided by wires, and includes all generating, measuring, switching, signaling and other means or methods incidental to or involved, in such communication.

"Wireless Telephony" is to be taken as meaning the same as the above, except that
3990 the waves, variations or impulses are radiated through space.

"Wire Telegraphy" is the art of communicating messages by code signals (such as the Morse Code, for example) by means of electricity, magnetism or electro-magnetic waves, variations or impulses conveyed or guided by wires, and includes all generating, measuring, switching signaling and other means or methods, incidental to or involved in such communication, but does not include such devices as annunciators, elevator signals, engine room telegraphs, etc.

"WIRELESS TELEGRAPHY" is to be taken as meaning the same as "wire telegraphy," except that the waves, variations or impulses are radiated through space.

"POWER PURPOSES" are defined as including all prime movers and their accessories and all generation, use, measurement, control and application of electricity for light, heat and power, but does not include any communication purposes. 3992

"HOUSEHOLD DEVICES" are electric or electrically operated devices designed primarily for domestic use, but do not include devices for communication purposes.

"TRANSOCEANIC" communication shall be understood to include all communication between two continents, or between a continent and an island more than one hundred miles from its shores; islands within one hundred miles of the shores of a continent being considered parts 3993
thereof. North America, including the Panama Canal Zone and all of Central America north thereof, is to be considered as one continent, and South America and all of Central America south of the Panama Canal Zone as another. This definition does not include communication between ships or between ships and shore.

"THE UNITED STATES GOVERNMENT" shall be understood to include not only the Federal Government but also the Governments of the Philippines, Porto Rico and other federal possessions, present or future; but shall not include any municipal, county or state government.

"Train Dispatching" is telegraphic or telephonic conveyance of train orders or operating information between the office of a train dispatcher or similar official and way stations, or other points along the line of way, or railway vehicles (with or without incidental provision for operating at will in an emergency, and not automatically, signals, brakes, stops and switches) for controlling the movements of trains or other automotive vehicles.

3995 "Railway Signalling" is the operation of signals, switches, brakes, stops, etc., controlling the movements of trains or other automotive vehicles, controlled by or in accordance with train or vehicle movements or track conditions, including block signalling, cab signals and train stops. It does not include train dispatching as above defined.

Any question arising as to the meaning or application of the foregoing definitions shall be settled by arbitration, as hereinafter provided.

3996 ## ARTICLE II.

The Patents Included in this Agreement.

The licenses provided for herein, are granted and agreed to be granted under all patents, and rights to or under patents, of the United States now or hereafter during the term of this agreement owned or controlled by the parties hereto, and under all such patents hereafter issued upon inventions now or hereafter during said term so owned or controlled, and to the extent to which the parties have or may have the right to grant licenses, Excepting as otherwise speci-

fied in connection with the several grants hereinafter contained, and EXCEPTING such patents and inventions as may be excluded from the operation of this agreement in the following manner.

A list of all United States patents under which it now holds transferable rights shall be furnished by each party to the other within sixty days from the date of this agreement. Such lists shall separately identify those patents, and shall
also include those applications, as to which rights, 3998
if granted hereunder, would be restricted in scope or would involve continuing obligations not implied by law. Copies of all contracts creating such restrictions or obligations shall, upon request, be furnished by each party to the other. Thereupon, and within six months after the receipt of the lists to be furnished as aforesaid, each party may in writing advise the other as to the patents and applications described in such list, furnished by the other, which (or the patents to issue on which) it desires to exclude from
this agreement; and no licenses are granted by 3999
this agreement under any patents so excluded. Each party shall thereafter, at such periods as may be agreed upon, or whenever requested by the other party, furnish to such other party like lists of subsequent patents and applications, and upon request therefor like copies of contracts; and each party may, within six months after the receipt of any such list, advise the other in writing as to the patents and applications described in such list which (or the patents to issue on which) it desires to exclude from this agreement; and no licenses are granted by this agreement under any patents so excluded.

ARTICLE III.

Scope of Licenses.

All of the licenses herein granted are, unless otherwise expressed in connection with the several grants, licenses to use methods and processes, and to make, use, lease, sell or otherwise dispose of apparatus, machines, devices, appliances and systems embodying the inventions of
4001 the several patents, in the fields in which the licenses are granted.

But no rights are granted to either party to manufacture, or to have manufactured, under patents under which it receives licenses hereunder, apparatus of the character at the time manufactured by the other party, except in factories owned or operated by one or the other of the parties hereto, or by their controlled companies, without the written consent of the party granting such licenses.

4002

ARTICLE IV.

Reservations and Exceptions to Which the Licenses Are Subject.

1. Each party reserves a non-exclusive right, under its own patents, to manufacture for and sell to the United States Government wireless devices, apparatus and systems, and to grant to that Government non-exclusive licenses to make or have made for it any wireless devices, apparatus and systems; but such devices, apparatus and systems are licensed to be sold to the Government only for governmental and not for

 4003

commercial uses or for toll, and not for resale, and the non-exclusive licenses which may be granted to the Government shall similarly be limited.

2. Each party reserves, under its own patents, rights in the fields and for the uses with reference to which it receives licenses under patents of the other party.

3. No licenses are granted by either party with reference to the manufacture and sale of 4004
wire or cable for the transmission of electric power or telephone currents.

4. No licenses are granted to the Telephone Company for electric lamps or other lighting devices (except non-exclusive licenses with reference to telephone and telegraph switchboard signal lamps and ballast lamps), nor for the working of tungsten. But the Telephone Company is licensed to use, in the fields for which it receives licenses hereunder, tungsten pur- 4005
chased from the General Company, or from others having the right to make and sell tungsten, and to make, use, sell or lease (for such fields only) devices embodying such tungsten. The General Company agrees to sell and deliver such tungsten for such purposes, in wire or other practicable form to be specified by the purchaser from time to time, on the terms specified in Article X hereof.

The Telephone Company agrees that, on all sales of telephone and telegraph switchboard lamps or ballast lamps, hereunder, to others than the Associated Companies of the Bell System,

it will pay to the General Company a royalty of 2% on the net sales price thereof.

5. The licenses hereinafter granted to the Telephone Company, in so far as they cover rights to sell or lease "carrier current," wireless or vacuum tube devices for use on electric railroads, are limited to the sales or leases of said devices to the railroads; all sales of such devices to be installed on electric cars or electric
4007 locomotives, as a part of the original construction and equipment thereof, shall be through the General Company only.

ARTICLE V.

Licenses Granted.

Subject to the foregoing reservations, each party grants and agrees to grant to the other the following licenses in the following fields of use:

4008 1. *Government Uses.*

Each party grants to the other non-exclusive licenses, to which all exclusive licenses herein granted are subject, to make any and all wireless apparatus and systems for and to sell the same to the United States Government, but only for governmental and not for commercial or toll uses and not for resale.

2. *Wireless Telegraphy.*

(*a*) The General Company grants to the Telephone Company non-exclusive licenses in the

field of wireless telegraphy for its own communication or for purposes of convenience or to save expense in connection with its commercial operation of wire telegraph and wire and wireless telephone systems, but not for profit or for transmission of messages for the public.

(*b*) Subject to the foregoing, the Telephone Company grants to the General Company exclusive licenses in the field of wireless telegraphy. 4010

3. *Wire Telegraphy.*

(*a*) The Telephone Company grants to the General Company non-exclusive licenses to make for its own operation and to operate wire telegraph systems, other than trans-oceanic; but no licenses are granted with reference to operation on lines leased to others than parties hereto or their subsidiary companies to which rights hereunder may be extended in accordance with subdivisions (*b*) of Section 3 of Article VI; and no 4011
licenses are granted with reference to trans-oceanic wire telegraphy.

(*b*) Subject to the foregoing, the General Company grants to the Telephone Company exclusive licenses in the field of wire telegraphy on land, and over ocean cables not more than one hundred miles in length, and between the main body of the United States and Cuba; but no licenses are granted with reference to other trans-oceanic wire telegraphy.

4012

4. *Wireless Telephony.*

(*a*) The Telephone Company grants to the General Company non-exclusive licenses in the field of wireless telephony for its own communication or for purposes of convenience, or to save expense in connection with its commercial operation of wireless telegraph systems, but not for profit or for transmission of messages for the public.

4013

(*b*) The Telephone Company grants to the General Company licenses (exclusive, except that the Telephone Company reserves exclusive rights for the uses and to the extent specified in subdivision *c* of this Section 4) in the field of trans-oceanic wireless telephony, such licenses being limited, so far as concerns service on this continent for the public or for others than the General Company, to rendering such service through only the Telephone Company's wire or wireless telephone systems, such limitation
4014 to exist so long as the Telephone Company remains in a position to and does supply that service. The General Company is, however, licensed to bring trans-oceanic wireless telephone messages by wire telephony to, and transmit them from a central or transfer point at a distance from its wireless stations (one such point for each pair of trans-oceanic stations) and the Telephone Company agrees that at such point it will establish communication with its system, but the Telephone Company shall not be required to accept any such point more than five miles from the nearest telephone central exchange of the Bell system. All service for the

public shall be through the Telephone Company's system, and shall be advertised as service of the Telephone Company through stations of the General Company when and so long as the General Company maintains facilities for the trans-oceanic wireless telephone service.

Joint through rates and the division of rates shall be agreed upon, it being agreed in principle that the General Company is entitled to its reasonable tolls between the central or transfer point and the distant country (including the amount, if any, paid to the foreign company with which communication is had), and that the Telephone Company is entitled to its reasonable tolls between the central or transfer point and the destination or sending point in the United States. 4016

(*c*) The General Company grants to the Telephone Company licenses (exclusive, except that the General Company reserves exclusive rights for the uses and to the extent specified in foregoing subdivision *b*) in the field of trans-oceanic wireless telephony, such licenses being limited, so far as concerns service, for the public or for others than the Telephone Company, to rendering such service through only the General Company's systems for trans-oceanic communication. But if and so long as the General Company is not prepared to and does not remain in a position to and does not supply such service, the Telephone Company may establish wireless stations for rendering such service, after giving the General Company reasonable notice and opportunity to do so, and shall have the right to continue to render such service through all such stations established by it except in so far as the 4017

General Company shall elect to co-operate in rendering such service, or any portion thereof, in which event the General Company shall take over those stations, or such of them as it shall elect, at the then cost of reproduction less depreciation. While the trans-oceanic service is being rendered through the General Company's stations, the advertising and the division of rates shall be as provided in foregoing subdivision *b* of this Section 4.

4019

(*d*) The Telephone Company grants to the General Company

(1) Exclusive licenses to make, use, lease and sell wireless telephone apparatus and systems for communication by and between airplanes, airships, ships and other automotive devices, except railway vehicles. The General Company is granted non-exclusive licenses to establish transmitting and receiving stations for communication with the
4020 foregoing, but is given no right to connect with any public service telephone system. The Telephone Company is licensed, but is under no obligation, to establish or maintain means by which such wireless telephone communication may be had with and through the Telephone Company's telephone system, and the Telephone Company is under no obligation to permit such communication. If, however, the Telephone Company shall establish, maintain or permit such wireless telephone communication through stations of third parties, other than the United States Government, it shall do the same with

respect to the General Company's stations on at least as favorable terms, including distribution of tolls, and engineering requirements. In case, at any time, the General Company has established such a station as is referred to in this paragraph, and the Telephone Company shall elect to co-operate or render such wireless service in any substantial part of the same territory, it shall purchase the said station of the General
Company at the then cost of reproduction 4022
less depreciation.

(2) Non-exclusive licenses to establish and maintain transmitting stations for transmitting or broadcasting news, music and entertainment from a transmitting station to outlying points, and licenses to make, use, sell and lease wireless telephone receiving apparatus for the reception of such news, music and entertainment so broadcasted. For the protection of the General Company un-
der the license which it receives in this para- 4023
graph, it is agreed that the Telephone Company has no license under this agreement to make, lease or sell wireless telephone receiving apparatus except as part or for direct use in connection with transmitting apparatus made by it; and for the protection of the Telephone Company under the licenses hereinbelow granted to it, it is agreed that the General Company has no license to equip wireless telephone receiving apparatus sold under this paragraph with transmitting apparatus, or to sell, lease or otherwise dispose of transmitting apparatus for use in

connection with receiving apparatus sold under this paragraph.

(3) Exclusive license to make, use, lease and sell all wireless telephone apparatus for amateur purposes.

(4) Exclusive licenses to make, use, lease and sell all wireless telephone apparatus (but not for public service) where the business use thereof is incidental (as for example for farmers), or where at least one of
4025 the stations is portable and is intended to be moved from place to place (as for example in lumbering operations) or where such wireless apparatus brings communication to new points not at the time served by the Telephone Company.

(5) Reserving to itself all exclusive license to make, use, sell and lease all wireless telephone apparatus to electric light, electric power and electric traction compa-
4026 nies for connection with wire or wireless public service telephone communication systems and receiving from the General Company a similar exclusive license of the same scope under the General Company's patents, the Telephone Company grants to the General Company exclusive licenses to make, use, sell and lease all wireless telephone apparatus for electric light, electric power and electric traction companies but only for the use of such companies and not for the use of the public, nor for toll, nor for the operation of a selective train dispatching system

and not for connection with any public service telephone system.

(*e*) The General Company grants to the Telephone Company:

(1) subject only to subdivisions (*a*), (*b*) and (*c*) and paragraph (1) of subdivision (*d*) of this Section, exclusive licenses in the field of wireless telephony to make, use, lease and sell all wireless telephone apparatus connected to or operated as a part of a public service telephone communication system, whether wire or wireless. 4028

(2) subject to all of the foregoing, exclusive licenses in the field of wireless telephony to make, use and sell for all business, public service and commercial uses of such character as might be served by leased wires, as for example brokers' offices, business houses, manufacturing plants, gas and water companies, mining companies, etc.

4029

(*f*) It is further agreed that in the fields of the exclusive licenses granted by paragraphs (3), (4) and (5) of Section (*d*) above and in paragraph (2) of Section (*e*) above, and for any wireless telephone uses not specified herein, each party will on application of the other party grant a license to the other party on reasonable terms for each specific installation for which such other party desires to manufacture and dispose of such wireless telephone apparatus; the license fee to be fixed with due regard to the benefits derived by the licensee and the disadvantages suffered by the licensor in the granting of such license.

5. *Wire Telephony.*

(*a*) The Telephone Company grants to the General Company licenses (exclusive, except that the Telephone Company reserves non-exclusive rights) to make and sell (but not to lease) to electric light, electric power and electric traction companies apparatus for so-called "carrier current" telephone communication over wires, or partly over wires and partly across wireless gaps, but in each instance only for the
4031 use of such companies and not for the use of the public, nor for toll, nor for operations of a selective train dispatching system, and not for connection with any public service telephone system.

(*b*) Subject to the foregoing, the General Company grants to the Telephone Company exclusive licenses in the field of wire telephony on land, and over cables not more than one hundred miles in length, and between the main body of the United States and Cuba; licenses are granted by
4032 each party to the other with reference to the other trans-oceanic wire telephony, such licenses being of the character and subject to the limitations and provisions expressed in foregoing subdivisions (*b*) and (*c*) of Section 4, with reference to trans-oceanic wireless telephony.

6. *Power Purposes and H usehold Devices.*

The Telephone Company grants to the General Company exclusive licenses in the fields of power purposes, household devices, and distance actuation and control by wireless for other than communication purposes. This grant is made with a reservation in so far as concerns patents

for inventions relating to business of the general character which any controlled Company of the Telephone Company now conducts as jobber, and any extensions of that business along similar lines. With reference to such patents (except those covering articles of the general character which such Company now purchases from the General Company, or its affiliated companies, or sells as agent for the same), the Telephone Company reserves under its own patents (but is granted no license under the patents of the 4034
General Company) the non-exclusive right for such controlled companies to make apparatus and devices embodying the inventions of said patents, or have them made for them, and to sell them in the said jobbing business.

7. *Railroad Signalling, X-ray Devices, Radio Goniometry.*

The Telephone Company grants to the General Company exclusive licenses in the fields of railroad signalling (other than train dispatching), X-ray devices and appliances associated 4035
therewith, and radio goniometry.

8. *Train Dispatching.*

Subject to the foregoing, the General Company grants to the Telephone Company exclusive licenses in the field of train dispatching.

9. *Submarine Signalling, Scientific Therapeutic Apparatus, Shop Expedients and Other Applications.*

Each party grants to the other, non-exclusive licenses in the following fields:

Submarine signalling.

Scientific apparatus for use of laboratories, colleges and scientific societies, as distinguished from commercial use.

Wireless apparatus for use of professional investigators (as distinguished from amateurs) for experimental purposes only.

Therapeutic apparatus other than X-ray devices and appliances.

Shop tools, appliances and processes, but only for the production of apparatus and
4037 devices embodying inventions which the grantee is licensed to make and use hereunder.

All applications, not herein otherwise specified, of inventions pertaining or applicable to or to the use of vacuum tubes, and to generating (directly or from other currents), modifying, amplifying, transmitting or receiving electro-magnetic waves, variations or impulses for other than power purposes, including instruments and their records for producing music and other sounds for amuse-
4038 ment or artistic purposes, with the right to transmit the sound by wire telephony throughout a building.

ARTICLE VI.

Provisions with Reference to Foregoing Licenses.

1. Whenever licenses granted under the terms of this agreement are based upon rights requiring the payment of royalties or other deferred payments, measured by the use made of the invention, the party accepting such licenses shall

make payments measured by its use of the invention at the same rate and upon the same terms as those agreed to be made by the party originally acquiring the rights.

2. The foregoing licenses shall continue respectively for the terms of the several patents issued or to be issued under which they are granted and agreed to be granted, and shall not be limited by the term of this agreement.

3. (*a*) The Telephone Company may grant sub- 4040
licenses under its standard form of license contract (a copy of which is now delivered to the General Company) to such operating companies as are now or may from time to time be operating under such form of contract. The provisions of this subdivision (*a*) shall apply to any changed form of license contract provided that, as changed, it grants rights in the fields of the General Company no broader than those granted by the present form.

(*b*) Subject to the foregoing sub-divisions (*a*), 4041
each party hereto may assign or grant sub-licenses under any of the rights granted hereunder, provided that in each instance the assent of the other party is first obtained.

(*c*) No disposition by either party of rights hereunder acquired by it, shall relieve such party of any of its obligations under this agreement, or restrict the rights of the parties hereto in operating under or modifying this agreement.

4. Each party agrees that, so far as it is enabled so to do, it will in disposing of devices embodying inventions pertaining or applicable to

vacuum tubes, or to generating, modifying, amplifying, transmitting or receiving electro-magnetic waves, or other devices or material the unrestricted sale of which would deprive the other party of rights to which it is entitled hereunder, use such precautions by contracts, restricted licenses or otherwise as may be necessary or advisable in order to prevent its customers or others from acquiring (by acquisition of devices from it or otherwise) licenses to use
4043 the same which the party disposing thereof has no right to grant.

5. The admission of validity implied in the acceptance of licenses hereunder is limited to the field for which such licenses exist.

6. One or the other of the parties hereto having already parted with rights under its inventions, present and future, in most of the foreign countries, it is agreed that the parties will co-operate with each other and with their foreign affiliated companies who may desire li-
4044 censes under the inventions of the other party, to the end that exchanges of licenses, may be effected in such countries. No licenses under foreign patents are now granted or are to be implied; but the licenses herein granted under United States patents include the right to manufacture and sell for uses abroad. Each party agrees not to export to any country in which the other party has an affiliated company, apparatus purchased from such other party which such other party could not itself so export, in view of existing contract obligations, after notice of such obligations and without first securing a written waiver thereof.

7. Each party represents that in its best judgment it has no outstanding obligations which would prevent it from entering into the agreements and from granting the licenses herein expressed. If, however, it is found that there are such conflicting obligations, the present agreement is made subject to the right to fulfil those obligations.

ARTICLE VII. 4046

Interferences.

The parties agree to use reasonable endeavors to settle, without litigation, interferences now pending or which may arise involving inventions within the scope of this agreement.

ARTICLE VIII.

Acquisition of Patent Rights. 4047

Neither party shall acquire from others rights to or under United States patents or inventions, or rights to use secret processes, applicable to the fields of the other party, of such limited character that the other party does not, by the operation of this agreement, receive licenses thereunder of the scope and within the respective fields herein set forth, unless the party proposing to acquire such rights shall first have given the other party an opportunity to be represented in the negotiations and thereby to acquire rights for its field.

ARTICLE IX.

Co-Operation and Exchange of Information.

1. Each party agrees that it will, from time to time during the term of this agreement, freely permit the other to have all information in its possession which it may have a right to disclose with reference to devices, apparatus, systems or methods applicable to the uses of the other party as herein defined, it being agreed that any
4049 secret process so disclosed shall be maintained in secrecy by the party to whom it is disclosed. Blue prints, etc., shall be furnished at the cost of preparing the same. Each party shall at all reasonable times have access (through a reasonably limited number of accredited representatives who are regular employees under obligation to assign inventions to their employer), to the laboratories, factories and wireless stations of the other, to the end that development work may be expedited and rendered the more effective.

4050 Each party shall, with reference to inventions owned or controlled by it and under which the other party is entitled to rights hereunder, endeavor to obtain or permit and aid the other to obtain proper patents thereon.

2. Publicity with reference to trans-oceanic telephony shall be joint, and shall recognize that the parties hereto, or their associates, have contributed equally to such work.

Engineering representatives shall be assigned by each of the parties to co-operate in the carrying out of the further work necessary for the development of trans-oceanic wireless telephony. In case trans-oceanic telephone service is given

from the plant of the Telephone Company through the stations of the General Company, these engineering representatives shall co-operate in the design of the apparatus and systems for this service, it being recognized that such systems and apparatus must be so designed as properly to fit in with the systems of the General and Telephone Companies respectively.

Each party shall afford the engineering representatives of the other the fullest possible
facilities, consistent with the reasonable opera- 4052
tion of the other, for experimenting and for developing and testing apparatus and systems for use in trans-oceanic telephony, and each shall at all times be given such an opportunity to make such tests, experiments and observations in the trans-oceanic stations of the other as do not conflict with the service then being rendered by such stations, and each party shall afford to the other such facilities for test, experimentation and observation on ships as it may be able to extend.

4053

3. In the operation of wireless and "carrier-current" communication, the parties shall co-operate to the end that interference with the operations of either party, due to the operations of the other, shall be minimized, it being recognized that the available wave lengths are limited.

ARTICLE X.

Purchases as Between Parties.

It is recognized that each party has and will normally continue to have facilities for manu-

4054 facturing certain apparatus or parts thereof which may be required by the other party under its licenses hereunder, and that a duplication of such facilities may be wasteful and uneconomical. Each party agrees that it will upon request manufacture for and sell and deliver to the other, with reasonable business promptness, on receipt of orders from time to time, and at favorable prices not to exceed those charged to others (except controlled companies) purchas-
4055 ing in like quantities for use in the United States, such apparatus and parts as the former is engaged in manufacturing from time to time and as the latter may desire for use under the licenses granted by this agreement.

ARTICLE XI.

Litigation.

Each party shall have the exclusive right to bring suits for infringement in the fields in
4056 which its licenses are herein expressed as exclusive (and the General Company may bring such suits for infringement in the field of trans-oceanic wire and wireless telephony) joining in any such suit the patent owner or the party which has acquired from the patent owner the right to sue thereunder.

Neither party shall bring suit for infringement of patents against the other party, or against the distributors and jobbing houses owned by or affiliated with either party, because of sales by such party, or by its (or its controlled companies) distributors or jobbing houses, of devices made, in the United States of

America, by others than the parties hereto, it being agreed that remedy in case of any such infringement shall be only by suit against the manufacturer of those devices.

ARTICLE XII.

Releases.

Each party reserves to itself the right to deal with the United States Government with reference to settlement for past use of its inventions 4058
in telephone and telegraph systems and apparatus. Subject to the foregoing, each party releases the other and the vendees and users of apparatus or systems made by it, from all claims growing out of past infringement of patents, by reason of the manufacture, use and sale of such apparatus and systems by the other party, and its resale or use by such vendees and users.

ARTICLE XIII.

Arbitration. 4059

In case any differences under this agreement (except in respect of interferences or priority of rights to inventions or patents) shall arise which the parties are unable to adjust between themselves, either party may, by notice in writing served on the other, designate one arbitrator and call upon the other to designate a second arbitrator within thirty days after the receipt of such notice; and the party receiving such notice agrees so to designate an arbitrator. The two arbitrators so designated shall promptly select a third arbitrator. The matter in dispute

shall be submitted to the three arbitrators so selected, and the parties agree that the concurring decision of any two of the above mentioned three arbitrators shall be final and binding upon them. Each party shall pay its own expenses, including the fees of its arbitrators, and the fees and expenses of the third arbitrator shall be paid one-half by each party.

ARTICLE XIV.

4061 ### Termination of Agreement.

(*a*) This agreement may, at any time, be terminated by mutual consent of the parties, in which event all licenses granted herein up to the date of such termination shall become non-exclusive and shall continue to the ends of the terms of the patents.

(*b*) Unless previously terminated as above provided, the duration of this agreement shall be ten years from the date hereof, but shall automatically continue in force thereafter until can-
4062 celed on three years' written notice given, after the expiration of said ten years' period, by one party to the other party.

(*c*) Upon any termination of this agreement (except under the provisions of Subdivision (*a*) of this Article XIV) all licenses, expressed herein as exclusive, shall remain exclusive during the life of the several patents.

ARTICLE XV.

Further Assurances.

The parties agree to execute and deliver such further instruments as may reasonably be neces-

sary for carrying out the provisions and purposes of this agreement.

ARTICLE XVI.

SUCCESSORS.

This agreement is binding upon and shall enure to the benefit of each of the parties hereto and their several successors in business, except that either party may transfer or dispose of any part or parts of its business not involving the 4064
grant of any licenses under this agreement, and in such case this agreement shall not be binding upon or inure to the benefit of the successor to that part of the business so transferred.

IN WITNESS WHEREOF, the parties hereto have caused this instrument to be executed on the day and year first above written, by their proper officers thereunto duly authorized.

GENERAL ELECTRIC COMPANY,
By E. W. RICE, JR.,
President. 4065

(SEAL)

Attest:

J. W. ELWOOD,
Assistant Secretary.

AMERICAN TELEPHONE & TELEGRAPH COMPANY,
By H. B. THAYER,
President.

(SEAL)

Attest:

A. A. MARSTERS,
Secretary.

4066 ## Defendant's Exhibit C.

Extension Agreement.

Whereas, a license agreement was entered into between the General Electric Company, a New York corporation herein called the General Company, and the American Telephone and Telegraph Company, a New York corporation herein called the Telephone Company, dated July 1, 1920, and

Whereas, the General Company desires to extend rights thereunder to the Radio Corporation
4067 of America, a Delaware Corporation (herein called the Radio Company) pursuant to the provisions of an agreement of November 20, 1919, between the General Radio Companies; and

Whereas, the Telephone Company desires to extend rights thereunder to the Western Electric Company, Incorporated, a New York Corporation (herein called the Western Company) pursuant to the provisions of an agreement of February 6, 1882, as modified by agreement of April 8, 1908, between the Telephone and Western
4068 Companies; and

Whereas, the Radio and Western Companies, respectively, desires to obtain such rights, but in accordance with Subdivision (*b*) of Section 3, Article VI of said agreement of July 1, 1920, such rights may be extended only with the assent of both parties to said agreement.

Now, it is agreed as follows:

1. The General Company may extend to the Radio Corporation, and the Telephone Company may extend to the Western Company (pursuant to the above mentioned agreements of November

 4069

20, 1919, February 6, 1882, April 8, 1908, or otherwise), any of the said rights reserved, and acquired by each respectively under this present agreement and under said agreement of July 1, 1920, whether or not expressed in said agreement of July 1, 1920, as personal or non-exclusive or non-assignable, except any right to terminate under the provisions of Article XIV of said agreement.

2. The Western Company hereby grants and agrees to grant to the General Company under 4070
the present and future patents of the Western Company, rights of the same character and scope, and for the same fields and subject to the same limitations and conditions, as the rights granted to the General Company in and by said agreement of July 1, 1920; PROVIDED, however, that all rights herein granted and agreed to be granted are subject to rights, which the Western Company hereby reserves for itself and for the Telephone Company and their several successors in business, of the same character and scope and
for the same fields and subject to the same limitations and conditions as the rights reserved by 4071
the Telephone Company in and by said agreement of July 1, 1920. And the Western Company hereby assumes towards the General Company (and the Telephone and Western Companies assume towards the Radio Company, to the extent that the General Company, under the provisions of Clause 1 hereof, extends or may hereafter extend its rights to the Radio Company) obligations similar to the obligations assumed by the Telephone Company towards the General Company in and by said agreement of July 1, 1920, except that the Western Company assumes

no obligations as to operation of telephone or telegraph systems unless and until it shall engage in the commercial operation of such systems.

3. The Radio Company hereby grants and agrees to grant to the Telephone Company, under the present and future patents of the Radio Company, rights of the same character and scope, and for the same fields and subject to the
4073 same limitations and conditions, as the rights granted to the Telephone Company in and by said agreement of July 1, 1920; PROVIDED, however, that all rights herein granted and agreed to be granted are subject to rights, which the Radio Company hereby reserves for itself and for the General Company and their several successors in business, of the same character and scope and for the same fields and subject to the same limitations and conditions as the rights reserved by the General Company in and by said agreement of July 1, 1920. And the Radio Com-
4074 pany hereby assumes toward the Telephone Company (and the General and Radio Companies assume towards the Western Company, to the extent that the Telephone Company, under the provisions of Clause 1 hereof, extends or may hereafter extend its rights to the Western Company) obligations similar to the obligations assumed by the General Company towards the Telephone Company in and by said agreement of July 1, 1920, except that the Radio Company assumes no obligations as to manufacturing or selling articles or devices which it is not from time to time engaged in commercially manufacturing.

4. This agreement shall terminate at the same time that the said agreement of July 1, 1920, terminates.

In Witness Whereof, the parties hereto have caused this instrument to be executed, in quadruplicate, on the first day of July, 1920, by their proper officers thereunto duly authorized.

General Electric Company,
By E. W. Rice, Jr.,
(seal) President. 4076

Attest:

J. W. Elwood,
Assistant Secretary.

Radio Corporation of America,
By E. J. Nally,
(seal) President.

Attest:

C. J. Ross,
Secretary.

4077

American Telephone & Telegraph Company,
By H. B. Thayer,
(seal) President.

Attest:

A. A. Marsters,
Secretary.

Western Electric Company, Inc.,
By H. A. Halligan,
(seal) President.

Attest:

George C. Pratt,
Secretary.

4078

Defendant's Exhibit D.

MODIFICATION
OF
LICENSE AGREEMENT

Dated July 1, 1920

GENERAL ELECTRIC COMPANY

AND

4079 AMERICAN TELEPHONE AND TELEGRAPH COMPANY

July 1, 1926

AGREEMENT dated July 1, 1926, between GENERAL ELECTRIC COMPANY, a New York corporation (herein called the General Company), and AMERICAN TELEPHONE AND TELEGRAPH COMPANY, a New York corporation (herein called the Telephone Company).

4080 WHEREAS, the parties hereto heretofore entered into an agreement made the first day of July, 1920, granting certain reciprocal licenses primarily in respect of electrical apparatus, but because at said date the art in certain of the fields dealt with in said agreement had not progressed to a point at which it was possible fully to comprehend the problems involved, disputes have arisen between the parties as to the meaning of various provisions of said agreement; and

WHEREAS, certain provisions of said agreement are not, as a practical matter, workable in the present state of the art; and

WHEREAS, unless said disputes are settled and said agreement made workable in practice progress in the fields dealt with in said agreement will be greatly hampered and delayed, and the parties desire to modify said agreement for the purpose of settling said disputes and making said agreement workable in practice;

Now, in consideration of the premises and the mutual agreements herein contained, the parties agree each with the other as follows: 4082

I. Said agreement made the first day of July, 1920 shall be and is modified to read as follows:

AGREEMENT made the first day of July, 1920, between General Electric Company, a New York corporation (herein called the General Company), and American Telephone and Telegraph Company, a New York corporation (herein called the Telephone Company).

WHEREAS, the General Company is engaged in the manufacture and sale in the United States of apparatus and systems for the generation, distribution and utilization of electricity for light, heat, power, traction and associated purposes, and in the manufacture and sale of a general line of electrical and power apparatus, and, directly and through subsidiaries, is engaged in the purchase of apparatus of various kinds from others and in the sale thereof; and is also engaged in the manufacture and sale of wireless apparatus; and 4083

WHEREAS, the Telephone Company and the Companies of the Bell System and their sub-

sidiaries are engaged in the operation of telephone and telegraph systems and in the manufacture, purchase and sale of telephone and telegraph and other electrical apparatus; and

WHEREAS, each party is in possession of information, patents and inventions applicable to, and has research organizations engaged in investigations bearing upon, not only its own business but also the business of the other party; and

4085

WHEREAS, various patents or applications for patents of the parties are involved in interference with each other in the United States Patent Office; and

WHEREAS, the restrictions upon each party imposed by the patent rights of the other and the uncertainties arising out of interferences have tended to, and if permitted to continue, will hamper and delay, progress in the development and production of wire and wireless telephone and telegraph and phonograph apparatus and
4086 systems; and

WHEREAS, the effective and prompt development of the arts in question can be secured only by the free and frank co-operation and exchange of information between the parties, which can not well take place if improvements and knowledge resulting from one party's co-operation with the other party may without its consent be made available in its field to the use of others;

Now, in consideration of the premises and the mutual agreements herein contained, it is agreed as follows:

ARTICLE I.

Definitions.

For the purposes of this agreement the following terms are defined as follows:

"*Wire telephony*" is the art of communicating or reproducing sound waves (created, directly or indirectly, by the voice or by musical instruments) by means of electricity, magnetism or 4088 electro-magnetic waves, variations or impulses conveyed or guided by wires, and includes all generating, measuring, switching, signaling and other means or methods incidental to or involved in such communication.

"*Wireless telephony*" has the same meaning as "wire telephony", except that the waves, variations or impulses are radiated through space.

"*Wire telegraphy*" is the art of communicating messages by code signals (such as the Morse Code, for example) and of picture transmission, 4039 by means of electricity, magnetism or electromagnetic waves, variations or impulses conveyed or guided by wires, and includes all generating, measuring, switching, signaling and other means or methods incidental to or involved in such communication, but does not include such devices as annunciators, elevator signals, engine room telegraphs, etc.

"*Wireless telegraphy*" has the same meaning as "wire telegraphy," except that the waves, variations or impulses are radiated through space.

4090 *"Picture transmission"* is the art of transmitting, or receiving at another point than the point of transmission, by means of electricity, magnetism or electro-magnetic waves, variations or impulses, the aspect or shape of things, including pictures, whether still or moving, drawings, writings, forms and other graphic, printed and written matter of all kinds; and include television.

4091 *"Programs"* means pictures, news, music, speeches, sermons, advertising and entertainment, educational and similar matter, or any of them or combinations of any of them, for the purpose of exhibition, entertainment or instruction.

"Power purposes" means all prime movers and their accessories and all generation, use, measurement, control and application of electricity for light, heat, power and traction, but does not include any communication purpose.

4092

"Public address system" means a combination of one or more telephone transmitters and one or more loud speaking telephone receivers, either adjacent to said transmitters or at a distance therefrom, operating by one-way wire telephony for the reproduction of sound with increased volume, but does not include apparatus for operation in combination or connection with or as parts of apparatus for (1) wireless telephone reception, or (2) reception of programs over electric light, electric heat, electric power or electric traction lines, or (3) the production or reproduction of sound from sound records.

"*Phonographs*" means all apparatus for the reproduction of sound from sound records used in or in connection with such apparatus, to be heard in the immediate vicinity of the apparatus, but does not include apparatus for the transmission to, or reception at, other points of sound reproduced from such records.

"*Electric Phonograph*" means a phonograph in which the sound record used therein gives rise to or controls an electric current or electromotive force in such a way that the variations 4094 of the electric current or electromotive force correspond in some way to the recorded sounds, and the electric current or electromotive force directly or indirectly brings about the production of the sound from the phonograph.

"*Transoceanic*" communication means all communication which crosses any ocean, gulf or sea between two continents, or between a continent and an island more than one hundred miles from its shores (islands within one hundred miles of the shores of a continent being considered parts 4095 thereof), or between two islands which are not parts of the same continent, except that communication between ships or aircraft, between ships and aircraft, or between ships or aircraft and shore, and communication between parts of the same continent, is not transoceanic communication. North America, including the Panama Canal Zone and all of Central America north thereof, is to be considered as one continent, and South America and all of Central America south of the Panama Canal Zone as another.

"*The United States Government*" means not only the Federal Government but also the Gov-

ernments of the Philippines, Porto Rico and other federal possessions, present or future; but does not include any municipal, county or state government.

"*Train dispatching*" is telegraphic or telephonic conveyance of train orders or operating information between the office of a train dispatcher or similar official and railway trains or other automotive land vehicles (not including
4097 airplanes or airships) or points along the line of way, for directing the movements of such automotive vehicles.

"*Railway signalling*" is the operation of signals, switches, brakes, stops, crossing gates, etc., controlling or signalling the movements of trains or other automotive vehicles, controlled by or in accordance with train or vehicle movements or track conditions, including block signalling, cab signals and train stops. It does not include train dispatching.

4098

"*Apparatus*" includes machines, devices and appliances and the materials entering into the construction thereof.

"*Household devices*" are electric or electrically operated apparatus, not herein otherwise specified, designed primarily for domestic use, but do not include apparatus for communication purposes.

"*Homes*" means all places of residence, permanent or temporary, including, however, as to hotels, hospitals and club houses only the private living rooms thereof.

"*Amateur*" means one, not a professional investigator, who is more than a mere broadcast listener and who evidences his interest in the art of wireless telephony by study, investigation or experiment in the art.

"*Subsidiaries*" of either party are corporations a majority of whose stock having power to vote for the election of directors is owned, directly or indirectly, either by such party, or by such party and one or more of its other subsidiaries, or by one or more of its other subsidiaries. 4100
The party hereto so controlling, directly or indirectly, any subsidiary is herein called the "*parent company*" of such subsidiary.

"*Companies of the Bell System*" are those companies which, in connection directly or indirectly with the Telephone Company, provide a telephone service throughout the United States, or from the United States to foreign countries. These companies at present comprise the Telephone Company, Western Electric Company, Incorporated, Cuban American Telephone and Telegraph Company, and the so-called Associate Companies and Connecting Companies, and their several subsidiaries. 4101

Any dispute arising as to the meaning or application of the foregoing definitions shall be settled by arbitration, as hereinafter provided.

ARTICLE II.

The Patents Included in this Agreement.

The licenses provided for herein are granted and agreed to be granted under all patents, and rights to or under patents, of the United States

now or hereafter during the term of this agreement owned or controlled by the parties hereto, and under all such patents hereafter issued upon inventions now or hereafter during said term so owned or controlled, and to the extent to which the parties have or may have the right to grant licenses, in so far as the inventions covered by such patents are or shall be applicable to the respective fields for which said licenses are expressed as granted or to be granted, excepting
4103 (1) as otherwise specified in connection with the several grants hereinafter contained, and (2) such patents and inventions as may hereafter be excluded from the operation of this agreement in the following manner:

A list of all United States patents under which it now holds transferable rights shall be furnished by each party to the other within sixty days from the date of this agreement. Such lists shall separately identify those patents, and shall also include those applications, as to which rights, if granted hereunder, would be restricted
4104 in scope or would involve continuing obligations not implied by law. Copies of all contracts creating such restrictions or obligations shall, upon request, be furnished by each party to the other. Thereupon, and within six months after the receipt of the lists to be furnished as aforesaid, each party may in writing advise the other as to the patents and applications described in such list, furnished by the other, which (or the patents to issue on which) it desires to exclude from this agreement; and no licenses are granted by this agreement under any patents so excluded.

Each party shall thereafter, at such periods as

may be agreed upon, or whenever requested by the other party, furnish to such other party like lists of subsequent patents and applications, and upon request therefor like copies of contracts; and each party may, within six months after the receipt of any such list, advise the other in writing as to the patents and applications described in such list which (or the patents to issue on which) it desires to exclude from this agreement; and no licenses are granted by this agreement under any patents so excluded. 4106

ARTICLE III.

Scope of Licenses.

1. All of the licenses herein granted are, unless otherwise expressed in connection with the several grants, licenses to use methods and processes, and to make, use, sell, lease or otherwise dispose of apparatus and systems in the fields in which the licenses are granted.

4107

2. A license to make apparatus includes a license to have such apparatus manufactured for the licensee by others, subject to the provisions of this article III and article X of this agreement. No rights are granted to either party to manufacture or to have manufactured, under patents under which it receives licenses hereunder, apparatus of the character at the time manufactured by the other party, except in factories owned or operated by one or the other of the parties hereto, or by their subsidiaries, without the written consent of the party granting such licenses.

4108 3. Every license herein granted to either party includes, unless otherwise herein provided, all incidental rights necessary to the full enjoyment and exercise of the license granted, notwithstanding that such incidental rights may lie primarily in a field in which the other party is herein granted a license which is denominated exclusive.

4. The making, using, selling, leasing or otherwise disposing of parts is subject to the same
4109 restrictions and conditions as are applicable under this agreement to apparatus of which they are or may be parts.

ARTICLE IV.

Reservations and Exceptions to Which the Licenses Are Subject.

1. Each party reserves, under its own patents, a non-exclusive right to make for and sell or lease to the United States Government wireless apparatus and systems for use only for
4110 other than commercial or toll purposes, and to grant to that government non-exclusive licenses to make or have made for it and to use wireless apparatus and systems, but only for other than commercial or toll purposes; and all exclusive licenses herein granted are subject to this reservation.

2. Each party reserves, under its own patents, rights in the fields and for the purposes with reference to which, and to the extent to which, it receives licenses under patents of the other party.

3. All exclusive licenses herein granted to either party are subject to licenses specifically herein granted to the other party and to rights incidental to the full enjoyment and exercise of all licenses granted to the other party, except as herein otherwise expressly provided.

4. No licenses are granted by either party with reference to the manufacture or sale of wire or cable for the transmission of electric current for light, heat, traction or other power 4112 purposes, or for telephone or telegraph purposes.

COPY

February 25, 1930.

G. E. Folk, Esq.,
American Telephone & Telegraph Co.,
195 Broadway,
New York City, N. Y.

4113

Dear Mr. Folk:

We understand that you are aware that the United States Government has raised objections to inclusion of the provision quoted hereunder in bids for radio apparatus:

> "This bid is made with the understanding that the apparatus furnished thereunder will be licensed under patents under which the bidder has the right to grant licenses for use or sale only for other than toll or

commercial purposes except to such extent as has been or may be prescribed by the Congress."

In prior discussion you have indicated that your company has no objection to sales of apparatus on contracts which omit the above provision. Under the circumstances and to make it a matter of record, we would like to have your company confirm this understanding and agree with us
4115 that the modification agreement dated July 1, 1926, Article V, Paragraph 1, entitled "Government Uses" should be amended by cancelling the words, "for use only for other than commercial or toll purposes."

We are sending herewith two signed copies of this letter. If the proposal meets with your approval kindly sign and return one copy to indicate your acceptance of the modification.

Very truly yours,

4116 General Electric Company,
(Sgd.) Albert G. Davis,
Vice President.

3/10/30
Approved until further notice.

(Sgd.) Walter Gifford,
President - A. T. & T. Co.

5. No licenses are granted to the Telephone Company for electric lamps or other lighting apparatus (except non-exclusive licenses with reference to telephone and telegraph signal lamps

and telephone and telegraph ballast lamps for use solely in fields in which the Telephone Company is otherwise licensed under this agreement), nor for the working of tungsten. But the Telephone Company is licensed to use, in the fields for which it receives licenses hereunder, tungsten purchased from the General Company, or from others having the right to make and sell tungsten, and to make, use, sell or lease (for such fields only) devices embodying such tungsten. The General Company agrees to sell and 4118
deliver such tungsten for such purposes, in wire or other practicable form to be specified by the purchaser from time to time, on the terms specified in article X hereof.

The Telephone Company agrees that, on all sales of telephone and telegraph signal lamps or telephone and telegraph ballast lamps, hereunder, to others than Companies of the Bell System, (other than lamps licensed under paragraph (*d*) of subdivision C of section 4 of article V hereof), it will pay to the General Company a royalty of 2% on the net sales price thereof. 4119

6. The licenses herein granted to the Telephone Company, in so far as they cover rights to sell or lease carrier current, wireless or vacuum tube apparatus for use on electric railroads, are limited to sales or leases of said apparatus to the railroads; the sale of such apparatus to be installed in electric cars and electric locomotives designed or built by the General Company, as part of the original construction and equipment thereof, shall be through the General Company only.

ARTICLE V.

Licenses Granted.

Subject to the foregoing reservations, each party grants and agrees to grant to the other the following licenses in the following fields of use:

1. Government Uses.

4121 Each party grants to the other non-exclusive licenses to make for, and sell or lease to, the United States Government wireless apparatus and systems for use only for other than commercial or toll purposes.

2. Wireless Telegraphy.

(*a*) The General Company grants to the Telephone Company licenses in the field of wireless telegraphy, exclusive except as in this paragraph (*a*) provided, for combined wireless tele-
4122 phone and telegraph sets for use on ships; but where such combined sets are for use on ocean-going and coastwise ships of American registry (excluding harbor tug-boats and other harbor craft) the exclusive right to use, lease, sell or otherwise dispose of the same is granted by the Telephone Company to the General Company. The Telephone Company agrees upon request to make such sets and sell them for such use to the General Company upon reasonable terms.

(*b*) The General Company grants to the Telephone Company non-exclusive licenses in the field of wireless telegraphy to make and use (but not

to sell, lease or otherwise dispose of, except to Companies of the Bell System) apparatus and systems for its own communication or that of Companies of the Bell System, and for use solely as an incidental facility in fields in which it is otherwise licensed under this agreement, but not for transmission of messages for the public except temporarily in emergencies due to storms or other catastrophes.

(*c*) The General Company grants to the Telephone Company non-exclusive licenses in the field of wireless telegraphy to make and use (but not to sell, lease or otherwise dispose of, except leases to subscribers in connection with a service given by Companies of the Bell System in this paragraph described) apparatus and systems for the purpose of giving within the continental United States, and between the continental United States and other parts of continental North America, a business, commercial or official service limited to a particular customer or class of customers and analogous to the service given by Companies of the Bell System by wire telegraphy at the date of this agreement, commonly designated as leased wire or special contract service, but said licenses do not include the making or using of such apparatus for (1) transmission or reception for the public generally or (2) transoceanic communication or (3) transmission or reception of programs; and the licenses granted to, and the rights reserved by, the Telephone Company for the purposes covered by this paragraph (*c*) include only apparatus for the reception of such service which shall be adapted for reception only upon the wave lengths (not

4124 (beside "(c) The General Company grants to the Tele-")

4125 (beside "customers and analogous to the service given by")

exceeding as to any set three specific wave lengths) upon which such service is given.

(*d*) The General Company grants to the Telephone Company non-exclusive licenses in the field of wireless telegraphy to make and use (but not to sell, lease or otherwise dispose of, except to Companies of the Bell System) apparatus and systems for television for use solely in combination with apparatus and systems for two-way tel-
4127 ephony for the purpose of giving a public service combining television and speech, but said licenses do not include the making or using of such apparatus for transmission or reception of programs.

(*e*) The General Company grants to the Telephone Company non-exclusive licenses in the field of wireless telegraphy for combined wireless telephone and telegraph sets, other than sets for transoceanic communication, (1) for use in communication by, with and between airplanes, air-
4128 ships and other automotive devices other than ships and railway vehicles, and (2) for export from the continental United States for use for any purpose other than transoceanic communication.

(*f*) Subject to non-exclusive rights reserved for the purpose described in paragraphs (*b*), (*c*), (*d*) and (*e*), of this section 2, the Telephone Company grants to the General Company exclusive licenses for all purposes in the field of wireless telegraphy other than for the purposes covered by paragraph (*a*) of this section 2 and by section 8 of this article V.

(*g*) The licenses granted to the General Company in this section 2 do not cover the use of wireless telegraph stations for giving a telephone service, except as licensed in section 4 of this article V. The General Company agrees that the surplus facilities of said stations of the General Company shall, upon request of the Telephone Company, be made available to the Telephone Company or its sub-licensees, upon reasonable terms to be agreed upon by the parties, for giving a two-way telephone service; and 4130
it shall be a condition of every sub-license granted by the General Company under the licenses granted to it in this section 2 that the sub-licensee shall be under like obligation in respect of its wireless telegraph stations embodying any invention in respect of which it is granted such sub-license.

3. Wire Telegraphy.

(*a*) The Telephone Company grants to the
General Company exclusive licenses in the field 4131
of wire telegraphy for the transmission and reception of programs over electric light, electric heat, electric power and electric traction lines, subject, however, to the provisions of paragraph (*b*) of section 5 of this article V regarding electrical interference.

(*b*) The Telephone Company grants to the General Company non-exclusive licenses in the field of wire telegraphy to make (but not to sell, lease or otherwise dispose of) apparatus and systems, and (1) to use such apparatus and systems for its own communication and for use

solely as an incidental facility in fields in which it is otherwise licensed under this agreement, and (2) to use such apparatus and systems upon wire telegraph systems owned by it, or leased to it, for its operation (other than transoceanic cables), for all purposes other than giving a service by wire telegraphy analogous to the service given by the Companies of the Bell System by wire telegraphy at the date of this agreement, commonly designated as leased wire or
4133 special contract service, and other than train dispatching; but no licenses are granted with reference to transoceanic wire telegraphy.

(*c*) The Telephone Company grants to the General Company non-exclusive licenses in the field of wire telegraphy for apparatus and systems for communication only in connection with the operation of apparatus for power purposes, but not for transmission of messages for the public.

(*d*) The Telephone Company grants to the
4134 General Company non-exclusive licenses in the field of wire telegraphy for apparatus and systems for communication between parts of a train (without regard to the nature of the motive power thereof), or between trains following or approaching each other upon the same system of tracks, or between trains approaching a cross-over or junction point of the systems of tracks upon which they are running, or between trains and signal towers or way-stations within short distances thereof, but in each instance only for use in connection with the operation of such trains but not for train dispatching.

(*e*) Subject to non-exclusive rights reserved for the purposes described in paragraph (*b*), (*c*) and (*d*) of this section 3, the General Company grants to the Telephone Company exclusive licenses for all purposes in the field of wire telegraphy (other than that covered by paragraph (*a*) of this section 3) on land, and over ocean cables not more than one hundred miles in length, and between the main body of the United States and Cuba; but no licenses are granted with reference to other transoceanic wire telegraphy. 4136

4. Wireless Telephony.

A. In general.

(*a*) The Telephone Company grants to the General Company non-exclusive licenses in the field of wireless telephony to make and use (but not to sell, lease or otherwise dispose of) apparatus and systems for its own communication and for use solely as an incidental facility in fields in which it is otherwise licensed under this agreement, but not for transmission of messages (as distinguished from programs) for the public except temporarily in emergencies due to storms or other catastrophes. 4137

(*b*) The Telephone Company grants to the General Company exclusive licenses in the field of amateur wireless telephony, subject to non-exclusive rights reserved for the purposes and subject to the limitations hereinafter in this paragraph (*b*) provided; and the General Company grants to the Telephone Company non-exclusive licenses to make and sell apparatus in the field

of amateur wireless telephony limited as hereinafter in this paragraph (*b*) provided. The licenses by this paragraph (*b*) granted by the Telephone Company to the General Company shall be free of royalties, but all apparatus sold by the Telephone Company under the licenses granted by this paragraph (*b*) shall be treated as if such apparatus were apparatus for one-way wireless telephone reception of programs under the provisions of paragraph (*d*) of subdi-
4139 vision C of this section 4 and shall be governed by all the provisions of said paragraph (*d*).

(*c*) Each party grants to the other non-exclusive licenses for headphones for all purposes in all fields covered by this agreement; provided, however, that headphones sold by the Telephone Company as part of complete apparatus for one-way wireless telephone reception of programs shall be included in the determination of the royalties payable by the Telephone Company under the provisions of paragraph (*d*) of subdi-
4140 vision C of this section 4.

(*d*) Each party grants to the other non-exclusive licenses in the field of wireless telephony for apparatus and systems for communication only in connection with the operation of apparatus for power purposes, but not for transmission of messages for the public.

(*e*) Each party grants to the other non-exclusive licenses in the field of wireless telephony for apparatus and systems for communication between parts of a train (without regard to the nature of the motive power thereof), or between

trains following or approaching each other upon the same system of tracks, or between trains approaching a cross-over or junction point of the system of tracks upon which they are running, or between trains and signal towers or way-stations within short distances thereof, but in each instance only for use in connection with the operation of such trains but not for train dispatching.

B. Two-way wireless telephony. 4142

(*a*) The General Company grants to the Telephone Company exclusive licenses in the field of two-way transoceanic wireless telephony to make and use (but not to sell, lease or otherwise dispose of) apparatus and systems for use in the continental United States; but such licenses do not include use for transmission or reception of messages offered for telephonic transmission.

(*b*) The General Company grants to the Telephone Company non-exclusive licenses in the 4143
field of two-way transoceanic wireless telephony, to make and sell to stations outside the continental United States engaged in cooperation with the Telephone Company in giving for the public a transoceanic telephone service, apparatus for use in giving such service; and subject to non-exclusive rights reserved for the purposes described in the foregoing clause of this paragraph (*b*), the Telephone Company grants to the General Company exclusive licenses in the field of two-way transoceanic wireless telephony for apparatus for export from the continental United States.

(*c*) The Telephone Company grants to the General Company non-exclusive licenses in the field of two-way wireless telephony for combined wireless telephone and telegraph sets, other than sets for transoceanic communication, (1) for use in communication by, with and between airplanes, airships and other automotive devices other than ships and railway vehicles, and (2) for export from the continental United States for use for any purpose other than transoceanic communi-

4145 cation.

(*d*) Subject to non-exclusive rights reserved for the purposes described in paragraph (*c*) of this subdivision B, the General Company grants to the Telephone Company exclusive licenses in the field of two-way wireless telephony (other than in the field of transoceanic wireless telephony) for all purposes other than the purposes covered by subdivision A of this section 4.

(*e*) The licenses granted to the Telephone Com-

4146 pany in this subdivision B do not include the use of wireless telephone stations for giving a telegraph service, except as licensed in section 2 of this article V. The Telephone Company agrees that the surplus facilities of said stations of the Telephone Company shall, upon request of the General Company, be made available to the General Company or its sub-licensees, upon reasonable terms to be agreed upon by the parties, for giving a wireless telegraph service; and it shall be a condition of every sub-license granted by the Telephone Company under the licenses granted to it in this subdivision B that the sub-licensee shall be under like obligation in respect of its

wireless telephone stations embodying any invention in respect of which it is granted such sub-license.

C. One-way wireless telephony.

(*a*) Each party grants to the other non-exclusive licenses in the field of one-way wireless telephony for apparatus and systems for the purpose of giving a business, commercial or official service limited to a particular customer or class 4148
of customers; but the licenses granted by this paragraph (*a*) do not include the making or using of such apparatus for (1) transmission or reception of messages for the public generally or (2) transmission or reception of programs; and the licenses granted to, and the rights reserved by, the Telephone Company for the purposes covered by this paragraph (*a*) include only apparatus for the reception of such service which shall be adapted for reception only upon the wave lengths (not exceeding as to any set three specific wave lengths) upon which such service 4149
is given and only apparatus for the transmission of such service from and within the continental United States.

(*b*) Each party grants to the other non-exclusive licenses in the field of one-way wireless telephony for apparatus and systems for use for transmitting for purposes other than that covered by paragraph (*a*) of this subdivision C, including, however, apparatus for wireless telephone reception furnished as a part of the equipment of transmitting stations; but the licenses granted by this paragraph (*b*) do not include

apparatus in the field of amateur wireless telephony.

(*c*) The General Company grants to the Telephone Company non-exclusive licenses to make and use (but not to sell, lease or otherwise dispose of, except to Companies of the Bell System) apparatus for one-way wireless telephone reception (including apparatus for the reception of programs) for its own communication or that
4151 of Companies of the Bell System, and for use solely as an incidental facility in fields in which it is otherwise licensed under this agreement.

(*d*) The General Company grants to the Telephone Company non-exclusive licenses to make and sell (but not to lease or otherwise dispose of) apparatus for one-way wireless telephone reception of programs, but not for use in combination or connection with phonographs; provided, however, that the licenses granted in this paragraph (*d*) shall be subject to the following terms
4152 and conditions:

(1) Tubes (thermionic devices) sold as separate devices for use in apparatus covered by this paragraph (*d*), or in apparatus which under other provisions of this agreement shall be treated as apparatus covered by this paragraph (*d*), shall be free of royalties to the amount of $2,000,000 during each calendar year, and said tubes in excess of said amount in any year shall be subject to a royalty of fifty per cent. computed as hereinafter provided; provided that in no event shall tubes sold free of royalty exceed 1,000,000 in number during any calendar year;

and provided further that where said tubes are sold as parts of receiving sets or other complete units designed for operation with such sets, such tubes shall be treated as parts of the receiving set or other unit and shall not be classified under this sub-paragraph (1).

(2) Receiving sets and apparatus which under other provisions of this agreement shall be treated as apparatus covered by this paragraph (*d*), or parts thereof (including loud speakers, amplifiers and tubes other than thermionic devices), 4154
shall be free of royalty to the aggregate amount of $3,000,000 in each calendar year, and such sets, apparatus or parts in excess of said amount shall be subject to a royalty of fifty per cent. computed as hereinafter provided; provided that if the sales of tubes sold as separate devices amount to less than $2,000,000 during any year, the amount of such deficiency shall be added to the amount of receiving sets, apparatus and parts which may be sold free of royalty in the same year. 4155

(3) For any portion of the first or last calendar year of this agreement, less than an entire calendar year, during which royalties shall be payable hereunder, the amounts which may be sold free of royalty shall be that proportion of the amounts which may be sold free of royalty in the entire calendar year which said fractional part of a calendar year bears to a calendar year.

(4) The licenses granted to the Telephone Company in this paragraph (*d*) to sell apparatus for one-way wireless telephone reception of pro-

4156 grams (and the licenses to sell apparatus which under other provisions of this agreement shall be treated as apparatus covered by this paragraph) are licenses for sale only at retail (except as to sales for export), either directly or through the Telephone Company's own direct agents and are subject to the condition that the Telephone Company shall retain in itself, or in one or more of its subsidiaries, title to the apparatus and control of its disposition until it
4157 is so sold.

(5) The aforementioned amounts sold free of royalty, and the amounts subject to royalty, shall (except as to sales for export) be based on the actual price at which the apparatus is sold at retail.

(6) Sales for export shall be included in determining the amounts sold free of royalty, and the amounts subject to royalty, on the basis of the price at which the sale is made.

4158

(7) In ascertaining the amount of the sales which are free from royalty and the amount of the sales upon which royalties are to be paid hereunder, where apparatus is sold any part of which embodies any invention of any of the patents included in this agreement, the selling price of the apparatus sold shall be taken as the basis; but apparatus not covered by any of the patents of the parties, when sold not assembled for operation with apparatus covered by such patents, shall not be taken into account in computing the amounts of sales which are free from royalty or the amount of sales which are subject to royalty,

unless such apparatus not covered by such patents is adapted for operation with apparatus covered by such patents and is sold in such manner that its sale or its use in connection with apparatus covered by such patents would, except for the licenses granted by this agreement constitute contributory infringement of patents of the parties under which exclusive licenses are granted to the General Company by this agreement. Where radio receiving sets are sold for use in combination with apparatus primarily designed as public address systems the sale price 4160
of the public address apparatus shall not be included in the amount of the sales which are free from royalty or the amount of the sales which are subject to royalty. Chemical primary batteries, wet or dry, and chemical storage batteries, not sold as part of apparatus upon which royalties are payable hereunder, or wiring in a building in connection with a sale of such apparatus, shall not be taken into account in computing the amount of sales which are free from royalty or the amount of sales which are subject to royalty. 4161

August 26, 1930.

The American Telephone and Telegraph
Company,
195 Broadway,
New York, N. Y.

Gentlemen:

Referring to the agreement between us dated July 1, 1926, modifying the license agreement

dated July 1, 1920, it is proposed that the arrangements set forth below be made effective:

In consideration of the rights hereinafter granted to the General Company by the Telephone Company and upon the conditions herein contained the General Company agrees that the provisions as to the methods of sale contained in sub-paragraph 4 of paragraph (d) of Sub-Division C of Section 4 of Article V of said agreement dated July 1, 1926, shall not apply
4163 to sales made by the Telephone Company or its subsidiaries of the following apparatus:

(1) Apparatus for one-way wireless reception of programs, except where such apparatus is for use in homes, and

(2) Loudspeakers, whether for use in homes or otherwise; provided, however, that the retail list prices of such apparatus shall be regarded as the actual selling prices thereof for the purposes of computing the
4164 amounts sold free of royalty, and the amounts subject to royalty.

The Telephone Company grants to the General Company the right (which the General Company may extend to the Westinghouse Electric and Manufacturing Company and the Radio Corporation of America and their wholly owned subsidiaries) to use and sell, in combination with apparatus used and sold under the licenses granted in paragraph (d) of Section 5 of Article V of said agreement of July 1, 1926, close-talking microphones manufactured by the West-

ern Electric Company, Incorporated, for announcing purposes to permit the voice of a speaker talking directly into the microphone to be reproduced by loud-speaking telephone receivers before an assembled audience or in rooms within a building or group of substantially adjacent buildings commonly owned or operated; provided, however, that no rights are herein granted for any uses of such microphones or other apparatus otherwise than to reproduce announcements spoken directly into (*i. e.* not more than 4166
a few inches away from) such close-talking microphones.

It is agreed that the rights granted by the General Company are granted upon the condition that the Western Electric Company, Incorporated, shall sell to the General Company (either directly or through the Graybar Electric Company, Inc.) all close-talking microphones required by the General Company for the purposes above described at said Graybar Electric Company's lowest established selling prices plus seven and one-half per cent. (7½%) to be in- 4167
cluded in the billing for such microphones.

The arrangement set forth in this letter shall become effective between the parties immediately upon acceptance in writing by the Telephone Company and shall remain, in effect until changed or terminated upon ninety (90) days' written notice given by either party to the other, provided that such notice shall in no event be given prior to six months from date of acceptance hereof by the Telephone Company.

If the above arrangements are satisfactory to you, will you please indicate your acceptance

thereof on this letter, which is written in triplicate, and return the two copies to us.

Yours very truly,

GENERAL ELECTRIC COMPANY,
(Sgd.) By GERARD SWOPE,
President.

Accepted:

4169 AMERICAN TELEPHONE & TELEGRAPH COMPANY,
(Sgd.) By WALTER S. GIFFORD,
President.

J. H. R.
C. M.

(*e*) Subject to non-exclusive rights reserved for the purposes covered by paragraphs (*b*), (*c*) and (*d*) of this subdivision C, the Telephone Company grants to the General Company exclusive licenses for apparatus and systems for
4170 one-way wireless telephone reception of programs.

(*f*) Subdivision A of this section 4 and paragraphs (*a*) to (*e*), inclusive, of this subdivision C are intended to make provision for all anticipated fields of use of apparatus for one-way wireless telephone reception. If it should develop that there are other fields of use of such apparatus not covered herein licenses shall be granted in such other fields of use to the respective parties in accordance with the principle underlying said other paragraphs of this subdivision C, with special reference to the interest of the General

Company in the field of one-way wireless telephone reception of programs, on the one hand, and of the Telephone Company in the field of one-way wireless telephone reception for giving a service of a business, commercial or official nature, on the other hand. If the parties can not agree with respect to such licenses, their respective rights shall be determined by arbitration in accordance with the provisions of article XIII.

5. Wireless Telephony. 4172

(*a*) The Telephone Company grants to the General Company exclusive licenses, subject to non-exclusive rights reserved for the same purposes, and the General Company grants to the Telephone Company non-exclusive licenses, in the field of wire telephony for apparatus for carrier current telephone communication, both one-way and two-way, over electric light, electric heat, electric power and electric traction lines, or partly over such lines and partly across wireless gaps, but in each instance only for the use 4173 of the owner or operator of such lines in the business of such owner or operator, and not for transmission of messages for the public except temporarily in emergencies due to storms or other catastrophes.

(*b*) The Telephone Company grants to the General Company exclusive licenses in the field of one-way wire telephony for apparatus for the transmission and reception of programs over electric light, electric heat, electric power and electric traction lines including the use of such lines for pick-up lines or for connecting two or

more separate electric systems in connection with the transmission or reception of programs over such lines or by means of wireless telephony, but not including the use of other wires for such purposes except as licensed in paragraph (*c*) of this section 5; provided, however, that no apparatus is licensed under this paragraph (*b*), or under paragraph (*a*) of section 3 of this article V, the use of which would electrically interfere unreasonably with the Telephone Company's systems
4175 of wire communication for which it is licensed under this agreement, as the same may now exist or may hereafter normally be developed, or with the Telephone Company's exclusive field of transmitting programs by wire telephony over lines other than electric light, electric heat, electric power and electric traction lines, and the Telephone Company shall be the sole judge of the existence of such unreasonable interference. The Telephone Company agrees whenever requested by the General Company, but at the expense of the General Company consented to by
4176 it before being incurred, to co-operate with the General Company in every reasonable way to enable the General Company to develop apparatus within the licenses granted by this paragraph (*b*) which will avoid such electrical interference.

(*c*) The Telephone Company grants to the General Company non-exclusive licenses in the field of wire telephony, both one-way and two-way, to make (but not to sell, lease, or otherwise dispose of) apparatus and systems, and to use such apparatus and systems solely upon systems owned by it, for its own communication and for use solely as an incidental facility in fields in

which it is otherwise licensed under this agreement, but not for transmission of messages (as distinguished from programs) for the public except temporarily in emergencies due to storms or other catastrophes. The Telephone Company agrees to furnish to the General Company, when requested, pick-up or connecting wires, if available, for its use in the transmission of programs to or from its stations for such transmission either by means of wireless telephony or over electric light, electric heat, electric power and 4178
electric traction lines, or for its use in electrical sound recording, on terms at least as favorable as the terms given to others than the General Company, and agrees that in furnishing such pick-up and connecting wires for such service there shall be no discrimination against the General Company; and, in addition to and without limitation of the licenses granted by the foregoing clauses of this paragraph (*c*), the General Company reserves non-exclusive rights in the field of wire telephony under its own patents only, for use in connection with providing for 4179
itself or obtaining from others such service or facilities if the Telephone Company shall in any case fail to furnish the same, and the non-exclusive rights so reserved may be assigned to or otherwise availed of by any other party from which the General Company shall obtain service or facilities.

(*d*) The Telephone Company grants to the General Company non-exclusive licenses in the field of wire telephony for apparatus for the distribution to an assembled audience, or to rooms within a building or a group of substantially ad-

jacent buildings commonly owned or operated, of
matter re-transmitted from apparatus for one-
way wireless telephone reception, or from appa-
ratus for reception in the field covered by para-
graph (*b*) of this section 5, or from phono-
graphs, in each case located in the immediate
vicinity of such audience or within the building
or group of buildings within which such distri-
bution is made.

(*e*) The Telephone Company grants to the Gen-
4181 eral Company non-exclusive licenses in the field
of wire telephony, both one-way and two-way,
for apparatus and systems for communication
only over wires used in connection with appara-
tus for remote control or actuation of apparatus
for power purposes and only in connection with
the operation of apparatus for power purposes,
but not for transmission of messages for the
public.

(*f*) The Telephone Company grants to the Gen-
eral Company non-exclusive licenses in the field
4182 of wire telephony, both one-way and two-way,
for apparatus for communication between parts
of a train (without regard to the nature of the
motive power thereof), or between trains fol-
lowing or approaching each other upon the same
system of tracks, or between trains approaching
a cross-over or junction point of the systems of
tracks upon which they are running, or between
trains and signal towers or way-stations within
short distances thereof, but in each instance only
for use in connection with the operation of such
trains but not for train dispatching.

(*g*) Subject to non-exclusive rights reserved
for the purposes covered by paragraphs (*c*), (*d*),

(*e*) and (*f*) of this section 5, the General Company grants to the Telephone Company exclusive licenses in the field of wire telephony, both one-way and two-way, for all purposes other than for the purposes covered by the paragraphs (*a*) and (*b*) of this section 5; provided, however, (1) that the licenses granted by this paragraph (*g*) for apparatus for reception of programs are licenses only to make and use in connection with a service of transmitting programs by wire telephony over lines other than electric light, elec- 4184
tric heat, electric power and electric traction lines, to lease to subscribers to such a service, and to sell only at retail (except as to sales for export) either directly or through the Telephone Company's own direct agents, and said licenses are subject to the condition that the Telephone Company shall retain in itself, or in one or more of its subsidiaries, title to the apparatus and control of its disposition until it is so sold, and (2) that all apparatus made, used, sold, leased or otherwise disposed of by the Telephone Company for distributing to an assembled au- 4185
dience or to rooms within a building or a group of substantially adjacent buildings commonly owned or operated, programs re-transmitted from apparatus for one-way wireless telephone reception or from apparatus in the field covered by paragraph (*b*) of this section 5, in each case located in the immediate vicinity of such audience or within the building or group of buildings within which such distribution is made, shall be treated as if such apparatus were apparatus for one-way wireless telephone reception of programs under the provisions of paragraph (*d*) of subdivision C of section 4 of this article V, and

shall be governed by all the provisions of said paragraph (*d*).

6. Power Purposes and Household Devices.

The Telephone Company grants to the General Company exclusive licenses in the fields of (*a*) distance actuation and control by wireless, (*b*) power purposes (including apparatus for distance actuation and control of apparatus for
4187 power purposes and apparatus for indicating at remote points the condition or position, of apparatus for power purposes) and (*c*) household devices, in each case for purposes other than communication purposes; provided, however, that in so far as concerns patents for inventions relating to business of the general character which any subsidiary of the Telephone Company now conducts as jobber and any extensions of that business along similar lines (except patents covering articles of the general character which such subsidiary now purchases from the General Com-
4188 pany, or its subsidiaries, or sells as agent for the same), the Telephone Company reserves under its own patents (but is granted no license under the patents of the General Company) the non-exclusive right for such subsidiaries to make apparatus embodying the inventions of said patents, or have them made for them, and to sell them in said jobbing business.

7. Railroad Signalling, Radio Goniometry X-ray Devices.

(*a*) The General Company grants to the Telephone Company non-exclusive licenses in the

field of radio goniometry for apparatus for use as part of apparatus in respect of which the Telephone Company is otherwise licensed under this agreement.

(*b*) The General Company grants to the Telephone Company non-exclusive licenses in the field of railway signalling for apparatus incidental to apparatus for train dispatching, for use only by the train dispatcher or similar official for operating at will, and not automatically, signals, 4190
switches, brakes and stops.

(*c*) Subject to non-exclusive rights reserved for the purposes covered by paragraphs (*a*) and (*b*) of this section 7, the Telephone Company grants to the General Company exclusive licenses in the fields of railroad signalling, X-ray apparatus and apparatus associated therewith, and radio goniometry.

8. Train Dispatching.

4191
The General Company grants to the Telephone Company exclusive licenses in the field of train dispatching.

9. Electric Sound Recording.

(*a*) The General Company grants to the Telephone Company exclusive licenses for electrical apparatus for the production of sound records (which records are for the private use of the maker, and not for commercial use or sale) in combination or connection with apparatus in the field of wire telephony other than in connection

with apparatus in the field covered by paragraph (*b*) of section 5 of this article V.

(*b*) The Telephone Company grants to the General Company exclusive licenses for electrical apparatus for the production of sound records (which records are for the private use of the maker, and not for commercial use or sale) in combination or connection with apparatus for one-way wireless telephone reception of pro-
4193 grams and with apparatus in the field covered by paragraph (*b*) of section 5 of this article V.

(*c*) The Telephone Company grants to the General Company exclusive licenses for electrical apparatus for the production in homes (which records are for the private use of the maker and not for commercial use or sale) of sound records of entertainment and educational matter, other than apparatus covered by paragraphs (*a*) and (*b*) of this section 9.

4194 (*d*) Each party grants to the other non-exclusive licenses for electrical apparatus for the production of sound records other than apparatus covered by paragraphs (*a*), (*b*) and (*c*) of this section 9.

(*e*) Nothing in this section 9 contained shall be construed as granting to either party any exclusive license with respect to electrical apparatus for the production of sound records for commercial use or sale, or for the production of master records intended to be used in manufacturing sound records for commercial use or sale.

10. Electrical Phonographs.

(*a*) The General Company grants to the Telephone Company exclusive licenses for electrical phonographs for use in combination or connection with apparatus in the field of wire telephony other than in combination or connection with apparatus in the field covered by paragraph (*b*) of section 5 of this article V; provided, however, that the licenses granted by this paragraph (*a*) for phonographs for private use in 4196
homes for entertainment and educational purposes are licenses only to make and use in connection with a service of transmitting programs by wire telephony over lines other than electric light, electric heat, electric power and electric traction lines, to lease to subscribers to such a service, and to sell only at retail (except as to sales for export) either directly or through the Telephone Company's own direct agents, and said licenses are subject to the condition that the Telephone Company shall retain in itself, or in one or more of its subsidiaries, title to the ap- 4197
paratus and control of its disposition until it is so sold.

(*b*) The Telephone Company grants to the General Company exclusive licenses for electrical phonographs in combination or connection with apparatus for one-way wireless telephone reception, and in combination or connection with apparatus in the field covered by paragraph (*b*) of section 5 of this article V.

(*c*) The Telephone Company grants to the General Company exclusive licenses for electri-

cal phonographs for private use in homes for all entertainment and educational purposes other than those covered by paragraphs (*a*) and (*b*) of this section 10.

(*d*) Each party grants to the other non-exclusive licenses for electrical phonographs for all purposes other than those covered by paragraphs (*a*), (*b*) and (*c*) of this section 10.

4199 *11. Apparatus for Co-ordination of Sound and Pictures.*

(*a*) The rights and licenses of the parties hereto in respect of apparatus for transmitting, receiving, recording or reproducing sound in coordination, synchronism or timed relation with the taking, transmission or projection of pictures shall, in so far as the fields of wire and wireless telegraphy and telephony, electrical sound recording and electrical phonographs are involved, be governed by the other provisions of

4200 this agreement relating to said fields.

(*b*) In so far as apparatus for the taking or projection of pictures and apparatus for co-ordinating, synchronizing or timing such taking or projection in relation to the recording or reproduction of sound are not covered by the provisions of paragraph (*a*) of this section 11, the Telephone Company grants to the General Company exclusive licenses for such apparatus for private use in homes for entertainment and educational purposes, and each party grants to the other non-exclusive licenses for such apparatus for all other purposes.

13. ***Submarine Signaling, Scientific and Therapeutic Apparatus, Shop Expedients and Other Applications.***

Each party grants to the other, non-exclusive licenses in the following fields:

Submarine signaling.

Scientific apparatus for use of laboratories, colleges and scientific societies, as distinguished from commercial use. 4202

Wireless apparatus for use of professional investigators (as distinguished from amateurs) for experimental purpose only.

Therapeutic apparatus other than X-ray devices and appliances.

Shop tools, appliances, materials and processes, but only for the production of apparatus embodying inventions which the grantee is licensed to make and use hereunder.

All applications, not herein otherwise specified, of inventions pertaining or applicable 4203
to or to the use of vacuum tubes, and to generating (directly or from other currents), modifying, amplifying, transmitting or receiving electro-magnetic waves, variations or impulses for other than power purposes.

ARTICLE VI.

Provisions with Reference to Forегoing Licenses.

1. Whenever licenses granted under the terms of this agreement are based upon rights held by

4204 the licensor under any agreement requiring the payment of royalties or other deferred payments, measured by the use made of the invention, the party accepting such licenses shall make payments measured by its use of the invention at the same rate and upon the same terms as those agreed to be made by the party originally acquiring the rights.

2. Upon the termination of this agreement under
4205 the provisions of article XIV hereof all licenses herein granted shall, during the terms of the several patents, issued or to be issued, in respect of which such licenses exist at the date of termination, continue unaffected and of the same scope and character, whether exclusive or non-exclusive, herein expressed, so far as the grantor thereof has the right to grant such licenses for such terms; and such licenses shall not be limited by the term of this agreement.

3. (*a*) The Telephone Company may grant sub-
4206 licenses under its standard form of license contract (a copy of which is now delivered to the General Company) to such operating companies (but not manufacturing companies) as are now or may from time to time be operating under such form of contract. The provisions of this paragraph (*a*) shall apply to any changed form of license contract provided that, as changed, it grants rights in the fields of the General Company no broader than those granted by the present form.

(*b*) Each party hereto may grant to its subsidiaries sub-licenses under the licenses granted

to it herein; provided, however, that each subsidiary to which a sub-license shall be granted (excepting, however, sub-licensees pursuant to paragraph (*a*) of this section 3) shall either have entered into an agreement with its parent company effectively subjecting to this agreement all United States patents then or thereafter during the term of this agreement owned or controlled by it, or have executed to the party hereto other than its parent company an instrument granting
to such other party licenses under said patents 4208
co-extensive with the licenses herein granted to such other party. Use by any subsidiary of any sub-license granted under this agreement shall for all purposes of this agreement, including determination of royalties payable hereunder, be deemed to be use by its parent company, and ownership, lease or operation of any telephone or telegraph system or station by any subsidiary shall be deemed to be ownership, lease or operation of such system or station by its parent company for all purposes of this agreement.

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(*c*) In addition to the sub-licensing provided for in the foregoing paragraphs (*a*) and (*b*), each party hereto may assign or grant sub-licenses under any of the rights granted to it hereunder, provided that in each instance the assent of the other party is first obtained.

(*d*) Each party may, subject to the provisions of section 4 of this article VI, sell or lease to any sub-licensee having a sub-license to use granted under the provisions of any of paragraphs (*a*), (*b*), and (*c*) of this section 3, apparatus for the use of such sub-licensee under

4210 such sub-license, notwithstanding that the party granting such sub-license may not be licensed under this agreement generally to sell, lease or otherwise dispose of such apparatus.

(*e*) All sub-licenses granted hereunder shall be subject to all limitations and obligations attaching to the apparatus or system in respect of which sub-licenses are granted, whether under the patents, or under the instruments by which
4211 any party acquired the patents or licenses under them, or under this agreement.

(*f*) No disposition by either party of rights hereunder acquired by it, shall relieve such party of any of its obligations under this agreement, or restrict the rights of the parties hereto in operating under or modifying this agreement.

4. Each party agrees that, so far as it is enabled so to do, it will, in disposing of apparatus embodying inventions pertaining or appli-
4212 cable to vacuum tubes, or to generating, modifying, amplifying, transmitting or receiving electro-magnetic waves, or other apparatus or material the unrestricted sale of which would deprive the other party of rights to which it is entitled hereunder, use such precautions by contracts, leases, restricted licenses or otherwise as may be necessary or advisable in order to prevent its subsidiaries, sub-licensees, customers or others from acquiring (by acquisition of apparatus from it or otherwise) licenses to use the same which the party disposing thereof has no right to grant. In case at any time either party shall claim that apparatus made by the other

and capable of use in fields in which the claimant
is exclusively licensed under this agreement, has
been sold in an amount exceeding the amount
reasonably required for use in fields in which
the maker is licensed under this agreement, the
parties shall endeavor by agreement to deter-
mine whether there has been such excess sales
of apparatus and, if so, for what periods and in
what quantities and the amount of the roy-
alties payable thereon as hereinafter provided;
and if the parties shall be unable to agree upon 4214
any of said matters, the dispute shall be settled
by arbitration as hereinafter provided. The party
making such claim shall, if it shall prove the
fact of excess sales, not be required to prove
with the definiteness which would be required in
a court of law or equity, the amount of such ex-
cess sales, but the arbitrators shall estimate such
amount as nearly as they can from such evidence
as may be furnished by the parties and the
amount so estimated shall be deemed to be the
amount of such excess sales. Upon any excess
apparatus so determined to have been sold the 4215
party making such excess sales shall pay to the
other party royalties equal to fifty per cent. of
the current retail price during the period which
such excess apparatus was sold.

5. All royalties payable under any provision of this agreement shall continue to be payable to the ends of the terms of the patents in respect of which such royalties are payable, notwithstanding any termination of this agreement.

6. The admission of validity implied in the acceptance of licenses hereunder is limited to the

field for which such licenses are granted or agreed to be granted.

7. No licenses under foreign patents are now granted or are to be implied; but except as herein otherwise expressly provided the licenses to make, sell, lease or otherwise dispose of, herein granted under United States patents include the right to make, sell, lease, or otherwise dispose of for use abroad in the fields for which such
4217 licenses under United States patents are granted, but not for use abroad in other fields. Each party agrees not to export to any country in which the other party has an affiliated company, apparatus purchased from such other party which such other party could not itself so export, in view of existing contract obligations, after notice of such obligations and without first securing a written waiver thereof.

8. Each party represents that in its best judgment it has no outstanding obligations which
4218 would prevent it from entering into the agreements and from granting the licenses herein expressed. If, however, it is found that there are such conflicting obligations, the present agreement is made subject to the right to fulfil those obligations.

ARTICLE VII.

Interferences.

The parties agree to use reasonable endeavors to settle, without litigation, interferences now pending or which may arise involving inventions within the scope of this agreement.

ARTICLE VIII.

Acquisition of Patent Rights.

Neither party shall acquire from others rights to or under United States patents or inventions, or rights to use secret processes, applicable to the fields of the other party, of such limited character that the other party does not, by the operation of this agreement, receive licenses thereunder of the scope and within the respective fields herein set forth, unless the party 4220
proposing to acquire such rights shall first have given the other party an opportunity to be represented in the negotiations and thereby to acquire rights for its field.

ARTICLE IX.

Co-operation and Exchange of Information.

1. Each party agrees that it will, from time to time during the term of this agreement, freely permit the other to have all information in its possession which it may have a right to dispose 4221
of with reference to its standardized apparatus or methods or processes applicable to the uses of the other party in fields in which such other party is granted licenses hereunder, but any secret process so disclosed shall be maintained in secrecy by the party to whom it is disclosed. Blue prints, etc., shall be furnished at the cost of preparing the same. For the purpose of acquiring such information each party shall at all reasonable times have access (through a reasonably limited number of accredited representatives who are regular employees under obligation to assign inventions to their employers), to the laboratories, factories and wireless stations

of the other, to the end that development work may be expedited and rendered the more effective.

Each party shall, with reference to inventions owned or controlled by it, under which the other party is entitled to rights hereunder and which either party deems to be of sufficient value to justify such action, endeavor to obtain or permit and aid the other to obtain proper patents thereon.

4223 2. Each party shall afford the engineering representatives of the other the fullest possible facilities, consistent with the reasonable operation of the other, for experimenting and for developing and testing apparatus and systems for use in transoceanic telephony, and each shall at all times be given such an opportunity to make such tests, experiments and observations in the transoceanic stations of the other as do not conflict with the service then being rendered by such stations, and each party shall afford to the other such facilities for test, experimentation and ob-

4224 servations on ships as it may be able to extend.

3. In the operation of wireless and carrier-current communication, the parties shall co-operate to the end that interference with the operations of either party, due to the operations of the other, shall be minimized, it being recognized that the available wave lengths are limited.

ARTICLE X.

Purchases as Between Parties.

It is recognized that each party has and will normally continue to have facilities for manu-

facturing certain apparatus or parts thereof which may be required by the other party under its licenses hereunder, and that a duplication of such facilities may be wasteful and uneconomical. Each party agrees that it will upon request manufacture for and sell and deliver to the other, with reasonable business promptness and within its reasonable manufacturing capacity, on receipt of orders from time to time, and at favorable prices not to exceed those charged to others (except subsidiaries and, in the case of the Tele- 4226
phone Company, Companies of the Bell System) purchasing in like quantities for use in the United States, such apparatus and parts as the former is engaged in manufacturing from time to time and as the latter may desire for use under the licenses granted by this agreement.

ARTICLE XI.

Litigation.

1. Each party shall have the exclusive right to 4227
bring suits for infringement in the fields in which its licenses are herein expressed as exclusive, joining as plaintiff in any such suit the patent owner or the party which has acquired from the patent owner the right to sue thereunder.

2. Neither party shall bring suit for infringement of patents against the other party, or against the distributors and jobbing houses owned by or affiliated with either party, because of sales by such party, or by its (or its subsidiaries') distributors or jobbing houses, of apparatus made, in the United States, by others

than the parties hereto, it being agreed that the remedy in case of any such infringement shall be only by suit against the manufacturer of those devices; but nothing herein contained shall be construed as the granting of a right to sell infringing apparatus manufactured by others.

3. Each party assigns and transfers to the other all claims and causes of action which it may have against others for infringement in
4229 fields in which the licenses herein granted to such assignee are exclusive, together with the right to sue for and collect for its own use all profits and damages arising out of such infringement.

ARTICLE XII.

Releases.

Each party reserves to itself the right to deal with the United States Government with reference to settlement for past use of its inventions in telephone and telegraph apparatus and systems. Subject to the foregoing, each party re-
4230 leases the other and the vendees and users of apparatus or systems made by it, from all claims growing out of past infringement of patents, by reason of the manufacture, use and sale of such apparatus and systems by the other party, and its resale or use by such vendees and users.

ARTICLE XIII.

Arbitration.

In case any controversy under this agreement (except in respect of interference or priority of rights to inventions or patents) shall arise between the parties to this agreement, which they

are unable to adjust between themselves, it shall be settled by arbitration pursuant to the Arbitration Law of the State of New York in the following manner:

Either party may by notice in writing served on the other, appoint one arbitrator and call upon the other to appoint a second arbitrator within thirty days after the receipt of such notice; and each party agrees that upon receiving any such notice it will so appoint an arbitrator. The two arbitrators thus appointed shall, 4232 within thirty days after the appointment of the one last appointed, jointly appoint a third arbitrator. The controversy shall be submitted to the three arbitrators in such manner as they shall direct and their decision, or the decision of a majority of them, rendered in writing, shall be final, conclusive and binding upon the parties. In the event that a second arbitrator shall not be appointed as above provided or the two arbitrators first appointed shall fail to appoint a third, application may be made by either party to the Supreme Court of the State of New York, 4233 or to a judge thereof, to designate and appoint an arbitrator or arbitrators, as the case may require, as provided by said Arbitration Law. Each party shall pay its own expenses in connection with the arbitration but the compensation and expenses of the arbitrators shall be borne in such manner as may be specified in their decision in writing.

ARTICLE XIV.

Termination of Agreement.

This agreement shall continue until July 1, 1933, but shall automatically continue thereafter

until cancelled on three years' written notice given after July 1, 1930, by one party to the other party.

ARTICLE XV.

Further Assurances.

The parties agree to execute and deliver such further instruments as may reasonably be necessary for carrying out the provisions and pur-
4235 poses of this agreement.

ARTICLE XVI.

Successors.

This agreement is binding upon and shall inure to the benefit of each of the parties hereto and their several successors in business, except that either party may transfer or dispose of any part or parts of its business not involving the grant of any licenses under this agreement, and in such case this agreement shall not be binding upon or inure to the benefit of the successors to
4236 that part of the business so transferred.

In witness whereof, the parties hereto have caused this instrument to be executed on the day and year first above written, by their proper officers thereunto duly authorized.

General Electric Company,
By E. W. Rice, Jr.,
President.

[seal]

Attest:

J. W. Elwood,
Assitant Secretary.

 4237

AMERICAN TELEPHONE AND TELEGRAPH COMPANY,
By H. B. THAYER,
President.

[SEAL]

Attest:

A. A. MARSTERS,
Secretary.

II. The foregoing modifications shall be effective from and after the date of this agreement. 4238

IN WITNESS WHEREOF, the parties hereto have caused this agreement to be executed as of the day and year first above written, by their proper officers thereunto duly authorized.

GENERAL ELECTRIC COMPANY,
By OWEN D. YOUNG,
Chairman of the Board.

[SEAL OF GENERAL ELECTRIC COMPANY]

Attest: 4239

J. W. LEWIS,
Assistant Secretary.

AMERICAN TELEPHONE AND TELEGRAPH COMPANY,
By D. F. HOUSTON,
Vice-President.

[SEAL OF AMERICAN TELEPHONE AND TELEGRAPH COMPANY]

Attest:

A. A. MARSTERS,
Secretary.

4240

Defendant's Exhibit E.

LICENSE AGREEMENT

(Power Supply & Amplifier Units)

BETWEEN

RADIO CORPORATION OF AMERICA, GENERAL ELECTRIC COMPANY and WESTINGHOUSE ELECTRIC &
4241 MANUFACTURING COMPANY

AND

AMERICAN TRANSFORMER CO.

1927.

LICENSE AGREEMENT

LICENSE AGREEMENT as of February 1st, 1927, by and between RADIO CORPORATION OF
4242 AMERICA, hereinafter termed Radio Corporation, GENERAL ELECTRIC COMPANY, and WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, hereinafter termed Licensors, and AMERICAN TRANSFORMER CO., a corporation of the State of N. J., hereinafter termed Licensee,

WITNESSETH:

THAT WHEREAS the Licensors represent that they severally own and/or have the right to grant licenses under various United States Let-

ters Patent relating to Power Supply and to Power Amplifier Units, hereinafter termed Licensed Apparatus, and

WHEREAS the Licensee desires to make lawful use of some or all of the inventions covered by said Letters Patent of the United States, and to that end desires to acquire the licenses herein expressed;

Now, THEREFORE, in consideration of the prem- 4244
ises, the licenses granted herein by the Licensors to the Licensee, and the covenants herein contained, it is agreed that:

1. Each of the Licensors hereby grants under all of the United States Patent useful in the Licensed Apparatus, owned by it and/or with respect to which it has the right to grant licenses, during the term of this Agreement or until it is sooner terminated as hereinafter provided for, and upon the terms and conditions hereinafter
set forth, and solely and only to the extent and 4245
for the uses hereinafter specified and defined, a personal, indivisible, non-transferable and non-exclusive license to the Licensee to manufacture at its factory located at 174-188 Emmet St., Newark, in the State of N. J.; and not elsewhere without previous written permission obtained from the Radio Corporation, and to sell only for radio amateur reception, radio experimental reception, and radio broadcast reception throughout the United States and its territories or dependencies, Licensed Apparatus so manufactured by the Licensee, except that no license is granted in this Agreement under any Letters Patent with

respect to which a Licensor has the right to grant licenses only upon condition of royalty or other consideration by said Licensor or its sublicensee.

Nothing herein contained shall be regarded as conferring upon the Licensee, either expressly or by estoppel, implication, or otherwise, a license to manufacture or sell any apparatus except such as may be manufactured by the Licensee in accordance with the express provisions of this
4247 Agreement. Nothing herein contained shall be construed as conveying any license expressly or by implication, estoppel or otherwise under any patents of countries foreign to the United States.

2. (*a*) That the term "amateur reception", for the purpose of this Agreement, means reception by one not a professional investigator who is more than a mere broadcast listener, and who evidences his interest in the art of wireless telephony by study, investigation, or experiment in the art.

4248

(*b*) That the term "experimental reception", for the purposes of this Agreement, means the use in a laboratory, college, school or scientific society or in professional investigations, but not in any case reception of messages, directly or indirectly for business purposes.

(*c*) That the term "broadcast reception", for the purpose of this Agreement, is defined as follows: The reception from radio telephone broadcast stations of news, music, speeches, sermons, advertising, and entertainments, educational and similar matter, or any of them, or combinations

of any of them, for the purpose of exhibition, entertainment or instruction.

3. The Licensee hereby agrees to pay to the Radio Corporation a royalty of seven and one-half per cent. (7½%) on the Licensee's net selling price of the Licensed Apparatus manufactured and sold by it during the continuance of this Agreement, except that no royalty shall be paid on, and no reports are required with reference to sales of apparatus purchased from or 4250
through the Radio Corporation. That for the purpose of this Agreement all Licensed Apparatus shall be considered as "sold" when the Licensed Apparatus has been billed out, or if not billed out, when it has been delivered, shipped, or mailed.

4. The Licensee within thirty (30) days after, and as of, the first days of January, April, July and October in each year respectively (hereinafter referred to as "Quarter Days"), shall furnish the Radio Corporation with written state- 4251
ments, under oath, specifying exactly the total number of Licensed Apparatus sold or otherwise disposed of under this Agreement by the Licensee during the preceding quarter. Said statements shall show the Licensee's net selling price with respect to all such Licensed Apparatus; the date when each was sold or otherwise disposed of, and the trade or brand name. The first of such statements shall be rendered not later than the fifteenth day after the Quarter Day next following the date of this Agreement, as of such Quarter Day and shall cover the period from the date of this Agreement to said Quarter Day.

4252 The royalty prescribed herein shall be due and payable on the 30th days of January, April, July and October of each year upon all such Licensed Apparatus sold or otherwise disposed of by the Licensee during the preceding quarter, or in the case of the first statement, the period covered thereby. The Licensee shall keep true, accurate and separate books of account containing all the information required to be given in the statements provided for in the preceding clause, and
4253 shall permit the Radio Corporation or its duly authorized agents or attorneys, at any time during the usual business hours, to inspect the same.

5. The Licensee shall affix to all Licensed Apparatus manufactured and sold by the Licensee under the terms of this Agreement, a license plate reading: "Licensed only for Radio Amateur, Experimental and Broadcast Reception" and the word "Patented", and giving the dates of the patents and which are, in the opinion of the Radio Corporation, used in such Licensed
4254 Apparatus. The Licensee further agrees that any and all catalogs, circulars or price lists, or general advertising, of the Licensee, shall contain a statement to the effect that the Licensed Apparatus so manufactured and sold by the Licensee, is "Licensed only for Radio Amateur, Experimental and Broadcast Reception", and that all such catalogs, circulars, or price lists, or general advertising, shall be subject to the approval of the Radio Corporation with respect to any reference to the Licensors or any of them, or to any matters relating to this Agreement.

6. In the event of the failure by the Licensee at any time during the continuance in force of

this Agreement to render any of the statements called for herein upon any of the prescribed dates, or to pay all the royalties required hereunder when due; or to comply with any of the other obligations of this Agreement, it is understood and agreed that should the Licensee refuse or neglect so to do for thirty (30) days after notification from the Radio Corporation by registered mail to the last known place of business of the Licensee, of the Licensee's failure in
any of these respects, this Agreement shall cease 4256
and terminate, at the option of the Licensor, thirty (30) days after notice in writing by registered mail to that effect has been forwarded to the Licensee, but no such cancellation shall release the Licensee from any of the liabilities accruing to the Licensor hereunder prior to the time such cancellation becomes effective. No failure on the part of the Radio Corporation to exercise its right of cancellation hereunder for any one or more defaults or breaches of covenant shall be construed to prejudice its right of
cancellation for any subsequent default or breach 4257
of covenant. Bankruptcy of the Licensee shall terminate this Agreement, and the Radio Corporation shall also have the right to terminate it upon the insolvency of the Licensee or the appointment of a receiver for its property.

7. Neither this Agreement or any of its benefits shall be directly or indirectly assigned, transferred, divided or shared by the Licensee with any person, firm, or corporation whatsoever, without the written consent of the Radio Corporation, but this Agreement shall inure to the benefit of the successor or assigns of the several

Licensors, but shall not inure to the benefit of the successors, assigns, or any legal representatives of the Licensee, without the consent of the Radio Corporation in writing having first been obtained.

8. Nothing herein contained shall be construed as conveying any licenses expressly or by implication, estoppel or otherwise to manufacture, use or sell vacuum tubes, except to use and sell the
4259 vacuum tubes purchased from the Radio Corporation as provided herein. The Radio Corporation hereby agrees to sell to the Licensee and the Licensee hereby agrees to purchase from the Radio Corporation the number, and only the number, of vacuum tubes to be used as parts of the circuits licensed hereunder and required to make initially operative the Licensed Apparatus such tubes to be sold by the Radio Corporation to the Licensee at the terms and at the prices at which they are then being sold by the Radio Corporation to other manufac-
4260 turers of the Licensed Apparatus buying in like quantities for the same purposes. But the sale of such tubes by the Radio Corporation to the Licensee shall not be construed as granting any licenses except the right to sell such tubes for use in, and to use them in, the Licensed Apparatus made and sold hereunder.

9. The Licensors or any of them or the American Telephone & Telegraph Company shall have the right to acquire for itself or for any corporation or corporations controlled by any of them through stock ownership of more than fifty per cent. of its issued stock, one or more

non-exclusive license or licenses on reasonable terms under any United States Letters Patent owned by the Licensee or under which it may have the right to grant a license or licenses. The terms of such license or licenses shall not be less favorable to the licensed party or parties than any other similar license from the Licensee, and such license or licenses shall remain in full force and effect during the term of this Agreement. If the terms of such license
or licenses cannot be agreed upon, then such 4262
terms shall be settled by arbitration pursuant to the Arbitration Law of the State of New York. The Licensee may terminate such right with respect to any Licensor and/or its controlled corporations as above defined and with respect to any specified Letters Patent by serving written notice upon any Licensor that unless said Licensor shall advise the Licensee in writing within six months of its intention to exercise said right with respect to Letters Patent specified in said notice, such right shall then
terminate at the end of such six months' period. 4263

10. The Licensors shall have the right to terminate this Agreement by the Radio Corporation giving written notice to the Licensee that this Agreement shall terminate one year from the date of such written notice, and this Agreement and all licenses thereunder shall thereupon terminate upon the date specified in said notice. The term of this Agreement shall be four and one-half (4½) years from February 1, 1927, unless sooner terminated, as hereinbefore provided. The termination of this Agreement, either four and one-half years from date or sooner,

shall not release the Licensee from any of its liabilities accruing prior to such termination.

IN WITNESS WHEREOF, the parties hereto have caused these presents to be executed by their proper officers thereunto duly authorized, and their corporate seals to be hereunto affixed, the day and year first above written.

RADIO CORPORATION OF AMERICA
4265 By (Sgd.) DAVID SARNOFF
(Seal) Vice President.

Attest

(Sgd.) L. MACCONNACH
Secretary

GENERAL ELECTRIC COMPANY
By (Sgd.) GERARD SWOPE
(Seal) President.

Attest
4266

(Sgd.) J. W. LEWIS
Asst. Secretary

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY
By (Sgd.) CHARLES A. TERRY
(Seal) Vice President.

Attest

(Sgd.) WARREN H. JONES
Asst. Secretary

American Transformer Co.
By (Sgd.) W. F. Hubley
(Seal) President.

Attest

(Sgd.) M. H. Harrold
Secretary

In consideration of the obligations contained in paragraph 9 of the foregoing Agreement, the American Telephone and Telegraph Company joins in and assents to the grant of the licenses hereinbefore granted by the Licensors. 4268

American Telephone and Telegraph Company
By (Sgd.) W. S. Gifford
(Seal) President.

Attest

(Sgd.) A. A. Marsters
Secretary 4269

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DEFENDANT'S EXHIBIT F

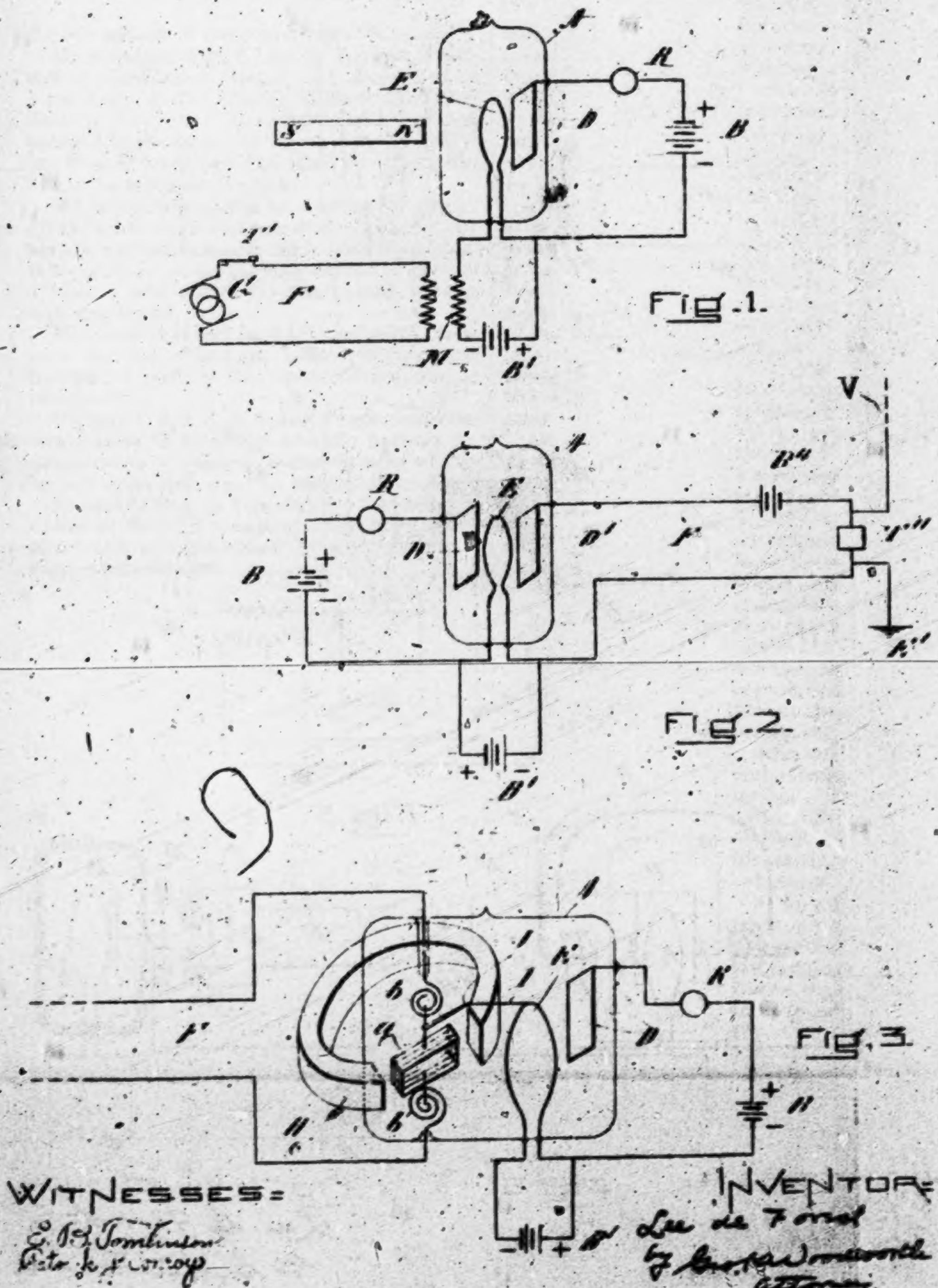
No. 841,387. PATENTED JAN. 15, 1907.

L. DE FOREST.

DEVICE FOR AMPLIFYING FEEBLE ELECTRICAL CURRENTS.

APPLICATION FILED OCT. 25, 1906.

2 SHEETS—SHEET 1.



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No. 841,387. PATENTED JAN. 15, 1907.

L. DE FOREST.

DEVICE FOR AMPLIFYING FEEBLE ELECTRICAL CURRENTS.

APPLICATION FILED OCT. 25, 1906.

2 SHEETS—SHEET 2.

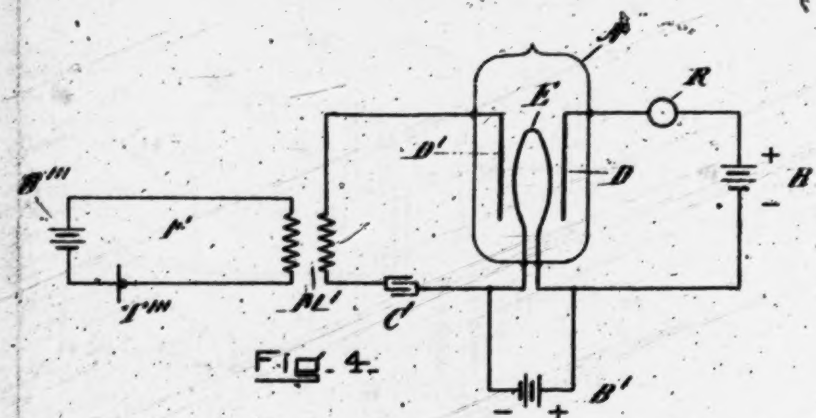

Fig. 4.

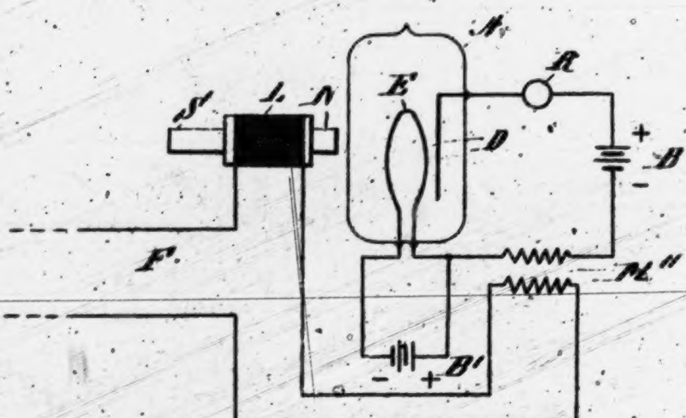

Fig. 5.

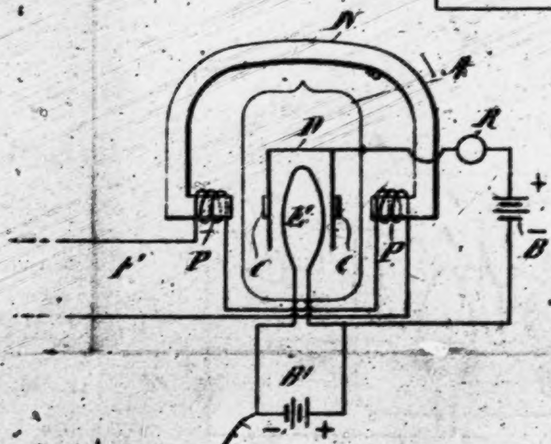

Fig. 6.

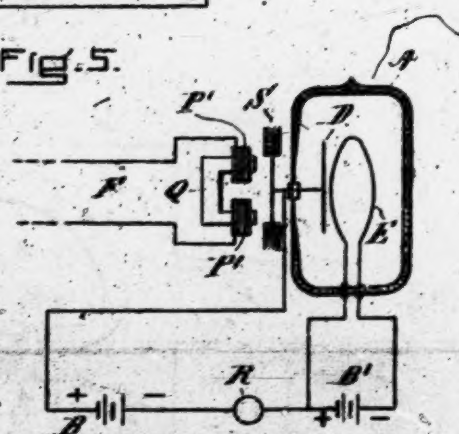

Fig. 7.

WITNESSES:

E. B. Tomlinson

Robert J. Emory

INVENTOR

Lee de Forest

by Geo. K. Woodworth

Attorney

UNITED STATES PATENT OFFICE.

LEE DE FOREST, OF NEW YORK, N. Y.

DEVICE FOR AMPLIFYING FEEBLE ELECTRICAL CURRENTS.

No. 841,387. Specification of Letters Patent. Patented Jan. 15, 1907.

Application filed October 25, 1906. Serial No. [illegible].

To all whom it may concern:

Be it known that I, LEE DE FOREST, a citizen of the United States, and a resident of New York, in the county of New York and State of New York, have invented a new and useful Improvement in Devices for Amplifying Feeble Electrical Currents, of which the following is a specification.

My invention relates to devices for amplifying feeble electrical currents—such, for example, as telephone-currents; and its object is to produce an amplifying device of greater efficiency and simplicity than those heretofore employed.

My invention will be described with reference to the drawings accompanying and forming a part of this specification, and in which—

Figures 1, 2, 3, 4, 5, 6, and 7 represent conventionally or diagrammatically various arrangements of apparatus and circuits whereby my invention may be carried into effect.

In the figures, A represents an evacuated vessel inclosing a sensitive conducting gaseous medium maintained in a condition of molecular activity.

R is a signal-indicating device.

B B are batteries or other sources of electrical energy.

D E D′ are electrodes sealed within the receptacle A.

The circuit B R D E is a local receiving-circuit. The circuit F is a line-circuit conveying the currents to be amplified to the amplifying device. The electrode E, which may be of platinum, tantalum, carbon, or other suitable material, is heated and preferably maintained incandescent by the battery B′. The electrodes D and D′, which may be plates of platinum or other suitable material, are placed in close proximity to the electrode E, and when the electrode D′ is employed its separation from the electrode E preferably is less than that of the electrode D therefrom.

In Fig. 1, N S represent a magnet placed adjacent to the vessel A. The currents to be amplified may be impressed upon the circuit which includes the heated electrode or filament E—as, for example, by means of the transformer M—and the magnetic field set up by these currents reacts upon the field set up by the magnet N S, thereby causing a slight variation in the separation between the electrodes D E. I have found that the slightest variation in the separation of the hot and cold electrodes produces a large and disproportionately greater variation in the flux between said electrodes, especially if the latter are close together, and such variation in flux may be made manifest by the signal-indicating device R.

In Fig. 2 the current to be amplified may be impressed upon the medium intervening between the electrodes D and E, and thereby alter, by electrostatic attraction, the separation between the electrodes. In this case D′ may be a strip of platinum-foil, and the slightest approach thereof toward the filament will act to slightly cool the gaseous medium, and thereby alter the current in the local circuit, or, if D′ is rigid, the increase in electrostatic attraction between D′ and E will cause E to recede from D, and thereby alter the current in the local circuit.

In Fig. 3 the filament E is connected, by means of a minute platinum wire I, to the arm J which is secured to the coil *a*, placed between the poles of the magnet H and secured to the walls of the vessel A through the spiral springs *b b*. The line-current to be amplified in this case is passed through the coil *a* through the springs *b b*, and the resulting rotation of the coil varies the separation between the electrodes D E, thereby altering the current in the local circuit.

In Fig. 4 the currents to be amplified may be impressed upon the gaseous medium intervening between D′ and E by means of the transformer M′. A condenser C may be included in series with the secondary of said transformer and the electrodes D′ E. In this case there may or may not be a variation between the separation of the electrodes, and the currents to be amplified may vary the motions of the ions around the filament, thereby controlling to a greater degree the flux between said filament and the electrode D.

In Fig. 5 the currents to be amplified may be passed through the solenoid surrounding the magnet N S, and thereby vary the field, which by coacting with the magnetic field surrounding the electrode E determines the normal separation of the electrodes D and E. Even without creating actual movements between the electrodes D and E the varying magnetic flux produced by the line-current passing through the solenoid L will affect the motion of the ions in the gaseous medium, and thereby alter the current in the local circuit.

In Fig. 6 the electrode D may be consti-

tuted of iron or may consist of platinum plates provided with small iron armatures O O. In either case the currents to be amplified by passing through the solenoids P P, which surround the poles of the magnet N, effect the desired variation in the separation of the electrodes D and E.

In Fig. 7 the electrode D and diaphragm S may both be rigidly secured to the inside and outside, respectively, of the glass wall of the vessel A at a point where said wall has been flattened and made very thin, like the crystal of a watch. The currents to be amplified in this case by operating upon the coils P' P', surrounding the magnet Q, effect slight movements of the diaphragm S, and these movements are mechanically transmitted through the glass wall of the vessel A to the electrode D, thereby varying the current in the local receiving-circuit.

It will be obvious that the amplifying device, which constitutes the subject-matter of the present invention, is not limited in its use to any particular kind of electrical circuit or apparatus, but that it is capable of general application wherever an amplifying device is required. By way of example of its application to a wire telegraph or cable system I have shown the line F in Fig. 1 as including a telegraph transmitting-key T' and source of vibratory current G. In Fig. 2 I have shown the line F as constituting the local circuit of a wireless-telegraph receiving system including the battery B'' and oscillation-detector T'', the latter being connected in series with an antenna V and the earth E'. In Fig. 4 I have shown the line F as constituting a telephone-circuit including the microphone-transmitter T''' and battery B'''. In all instances it will be understood by those skilled in the art and without going into further detail that the signal-indicating device R, which is included in the local receiving-circuit, may be any device suitable for the purpose of reproducing the signal initiated in the line F.

I do not limit myself to any of the specific embodiments of my invention herein described, inasmuch as many modifications will readily occur to those skilled in the art without departing from the principle of my invention.

I claim—

1. In a device for amplifying electrical currents, an evacuated vessel inclosing a sensitive conducting gaseous medium maintained in a condition of molecular activity, two electrodes sealed within said vessel, a local receiving-circuit associated with said electrodes, and means whereby the separation of said electrodes may be varied by the curren[ts] to be amplified.

2. In a device for amplifying electrical cu[r]rents, an evacuated vessel, two electrod[es] sealed within said vessel, means for heatin[g] one of said electrodes, a local receiving-ci[r]cuit associated with said electrodes, an[d] means whereby the separation of said ele[c]trodes may be varied by the currents to b[e] amplified.

3. In a device for amplifying electrical cu[r]rents, an evacuated vessel, two electrod[es] sealed within said vessel, a circuit includin[g] a source of electric energy connected in s[e]ries with one of said electrodes, a local recei[v]ing-circuit associated with said electrode[s] and means whereby the separation of sa[id] electrodes may be varied by the currents [to] be amplified.

4. In a device for amplifying electrical cu[r]rents, an evacuated vessel, three electrod[es] sealed within said vessel, means for heati[ng] one of said electrodes, a local receiving-c[ir]cuit including two of said electrodes, a[nd] means for passing the current to be amplifi[ed] between one of the electrodes which is i[n]cluded in the receiving-circuit and the thi[rd] electrode.

5. In a device for amplifying electrical cu[r]rents, an evacuated vessel inclosing a gase[ous] medium, means other than the received e[n]ergy for maintaining said gaseous medium [in] a condition of molecular activity, means f[or] impressing the currents to be amplified up[on] said gaseous medium, and a local receivin[g] circuit having electrodes sealed with[in] said vessel.

6. In a device for amplifying electrical cu[r]rents, an evacuated vessel, a heated el[ec]trode and two non-heated electrodes seal[ed] within said vessel, the non-heated electro[des] being unequally spaced with respect to s[aid] heated electrode, a local receiving-circuit [in]cluding said heated electrode and that one [of] the non-heated electrodes which has t[he] greater separation from the heated electro[de,] and means for passing the current to be a[m]plified between the heated electrode and t[he] other non-heated electrode.

In testimony whereof I have hereunto s[ub]scribed my name this 17th day of Octob[er,] 1906.

LEE DE FOREST

Witnesses:
RALPH POLK BUELL,
SIDNEY WILLIAMS.

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1428

No. 879,532. **PATENTED FEB. 18, 1908.**

L. DE FOREST.

SPACE TELEGRAPHY.

APPLICATION FILED JAN. 29, 1907.

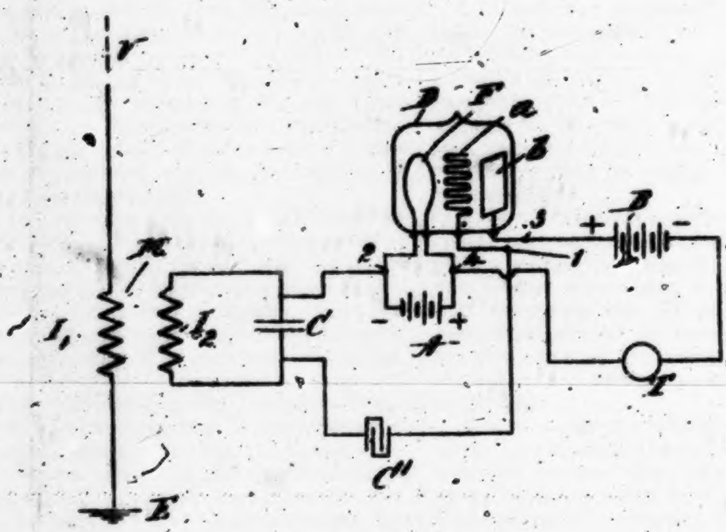
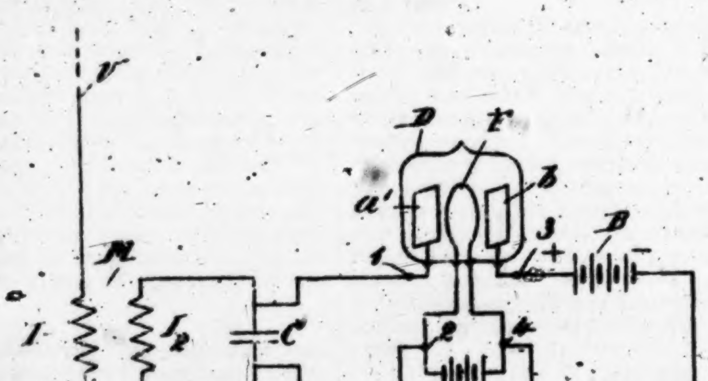


FIG. 1.



WITNESSES-

E. B. Tomlinson

Patrick J. Conroy

FIG. 2.

INVENTOR:

Lee de Forest

by Geo. K. Woodworth

Atty.

UNITED STATES PATENT OFFICE.

LEE DE FOREST, OF NEW YORK, N. Y., ASSIGNOR, BY MESNE ASSIGNMENTS, TO DE FOREST RADIO TELEPHONE CO., A CORPORATION OF NEW YORK.

SPACE TELEGRAPHY.

No. 879,532. Specification of Letters Patent. Patented Feb. 18, 1908.

Application filed January 29, 1907. Serial No. 354,362.

To all whom it may concern:

Be it known that I, LEE DE FOREST, a citizen of the United States, and a resident of New York, in the county of New York and State of New York, have invented a new and useful Improvement in Space Telegraphy, of which the following is a specification.

My invention relates to wireless telegraph receivers or oscillation detectors of a type heretofore described in my prior Letters Patent Nos. 824,637, June 26, 1906 and 836,070, November 13, 1906.

The objects of my invention are to increase the sensitiveness of oscillation detectors comprising in their construction a gaseous medium by means of the structural features and circuit arrangements which are hereinafter more fully described.

My invention will be described with reference to the drawings which accompany and form a part of the present specification, although it is to be understood that many modifications may be made in the apparatus and systems herein described without departing from the principles of my invention.

In the drawings, Figure 1 represents in diagram a wireless telegraph receiving system comprising an oscillation detector constructed and connected in accordance with the present invention and Fig. 2 represents a space telegraph receiving system having a modified form of oscillation detector connected therein in a manner which constitutes one of the subjects matter of said invention.

V I, E is an elevated conductor system including the elevated conductor V, earth connection E, and primary I, of the transformer M, the secondary I, of which forms part of the tuned receiving circuit I, C. It will be understood of course that the aforesaid tuned receiving circuit may be associated with the elevated conductor system in any suitable manner.

D represents an evacuated vessel, preferably of glass, having sealed therein three conducting members, F, *a* and *b*, in Fig. 1 and F, *a'* and *b* in Fig. 2. The conducting member or electrode F is shown as consisting of a filament, preferably of metal, which is connected in series with the battery A or other source of electrical current of sufficient strength to heat said filament, preferably to incandescence. The conducting member *b*, which may be a plate of platinum, has one end brought out to the terminal 3. Interposed between the members F and *b* is a grid-shaped member *a*, which may be formed of platinum wire, and which has one end brought out to the terminal 1. The local receiving circuit, which includes the battery B, or other suitable source of electromotive force, and the signal indicating device T, which may be a telephone receiver, has its terminals connected to the plate *b* and filament F at the points 3 and 4 respectively. The means for conveying the oscillations to be detected to the oscillation-detector, are the conductors which connect the filament F and grid *a* to the tuned receiving circuit and, as shown, said conductors pass from the terminals 2 and 1 to the armatures of the condenser C.

I have determined experimentally that the presence of the conducting member *a*, which as before stated may be grid-shaped, increases the sensitiveness of the oscillation detector and, inasmuch as the explanation of this phenomenon is exceedingly complex and at best would be merely tentative, I do not deem it necessary herein to enter into a detailed statement of what I believe to be the probable explanation.

In associating an oscillation detector of the above mentioned type, said detector being now commonly known as the audion, with a closed tuned circuit, it will be noted by reference to Fig. 2, that the secondary I, closes a circuit containing a battery shown at B through the electrode *b*, conducting member *a'* and the conducting gaseous medium intervening between said electrode and member. Also by reference to Fig. 1, it will be seen that a similar closed circuit exists between said battery, and the electrode *b* and conducting member *a*. In order to close each of said circuits to the passage of direct current from the aforesaid battery therethrough, or to prevent the development of a difference of potential between the members *a* and *b*, or between *a'* and *b*, or to prevent the members *a* or *a'* from receiving an electrical charge from said battery, I insert the condenser C' in said otherwise mechanically closed circuit and find that the presence of said condenser produces a great increase in the sensitiveness of the oscillation detector as determined by the very marked increase in the sound produced in the telephone T

when said condenser is present over the sounds produced therein under the same conditions when said condenser is not employed.

It will be understood that the circuit arrangements herein described with reference to the particular forms of audion herein disclosed may with advantage also be employed with various other types of audion.

I claim:

1. An oscillation detector comprising an evacuated vessel, an electrode inclosed therein, means for heating said electrode, a second electrode inclosed within said vessel, a local circuit having its terminals electrically connected to said electrodes, a conducting member inclosed within said vessel and located between said electrodes, and means for conveying the oscillations to be detected to the first mentioned electrode and said conducting member.

2. An oscillation detector comprising an evacuated vessel, two electrodes inclosed within said vessel, means for heating one of said electrodes, and a conducting member inclosed within said vessel and interposed between said electrodes.

3. An oscillation detector comprising an evacuated vessel, two electrodes inclosed within said vessel, means for heating one of said electrodes, and a grid-shaped member of conducting material inclosed within said vessel and interposed between said electrodes.

4. An oscillation detector comprising an evacuated vessel, a filament sealed therein, a source of electrical energy connected in series with said filament, an electrode sealed in said vessel, a local circuit having its terminals connected to said filament and electrode, respectively, said local circuit including a source of electromotive force and a signal indicating device, a grid of conducting material sealed in said vessel and interposed between said filament and electrode, and means for conveying the oscillations to be detected to said filament and grid.

5. An oscillation detector comprising an evacuated vessel, an electrode inclosed therein, means for heating said electrode, a second electrode inclosed within said vessel, a local circuit having its terminals connected to said electrodes, a conducting member inclosed within said vessel and located between said electrodes, a closed circuit for conveying the oscillations to be detected to said first mentioned electrode and conducting member, and a condenser in said closed circuit.

6. An oscillation detector comprising an evacuated vessel, two electrodes inclosed therein, means for heating one of said electrodes, a conducting member inclosed within said vessel and interposed between said electrodes, means for establishing a difference of electrical potential between said electrodes and means for preventing said conducting member from becoming electrically charged.

7. An oscillation detector comprising an evacuated vessel inclosing a sensitive conducting gaseous medium, three conducting members inclosed therein, a closed oscillation circuit, a circuit connecting an element of said oscillation circuit with two of said members, a condenser in said circuit, a signal-indicating device, and a circuit connecting said device with one of said two members and with the third member.

8. An oscillation detector comprising an evacuated vessel, two electrodes inclosed therein, means for heating one of said electrodes, a conducting member inclosed within said vessel and interposed between said electrodes, means for establishing a difference of electrical potential between said electrodes and means for preventing the establishment of a difference of electrical potential between one of said electrodes and said conducting member.

9. An oscillation detector comprising an evacuated vessel, two electrodes inclosed therein, means for heating one of said electrodes, a grid of conducting material inclosed within said vessel and interposed between said electrodes, means for establishing a difference of electrical potential between said electrodes and means for preventing said grid from becoming electrically charged.

10. An oscillation detector comprising an evacuated vessel, two electrodes inclosed therein, means for heating one of said electrodes, a grid of conducting material inclosed within said vessel and interposed between said electrodes, means for establishing a difference of electrical potential between said electrodes and means for preventing the establishment of a difference of electrical potential between one of said electrodes and said grid.

11. An oscillation detector comprising an evacuated vessel, an electrode inclosed therein, means for heating said electrode, a second electrode inclosed within said vessel, a local circuit having its terminals electrically connected to said electrodes, a grid of conducting material inclosed within said vessel and located between said electrodes, and means for conveying the oscillations to be detected to the heated electrode and grid.

12. An oscillation detector comprising an evacuated vessel, an electrode inclosed therein, means for heating said electrode, a second electrode inclosed within said vessel, a local circuit having its terminals connected to said electrodes, a grid of conducting material inclosed within said vessel and located between said electrodes, a closed circuit for conveying the oscillations to be detected to the heated electrode and grid, and a condenser in said closed circuit.

13. An oscillation detector comprising an

evacuated vessel, an electrode inclosed therein, means for heating said electrode, a second electrode inclosed within said vessel, a local circuit having its terminals electrically connected to said electrodes, said local circuit including a source of electromotive force and a signal indicating device, a grid of conducting material inclosed within said vessel and located between said electrodes, and means for conveying the oscillations to be detected to the heated electrode and grid.

14. An oscillation detector comprising an evacuated vessel, two electrodes, one of which is a filament, inclosed within said vessel, means for heating said filament, and a conducting member inclosed within said vessel and interposed between said electrodes.

15. An oscillation detector comprising an evacuated vessel, two electrodes inclosed within said vessel, means for heating one of said electrodes, a grid of conducting material inclosed within said vessel and interposed between said electrodes, a local circuit connecting said electrodes, and a source of electromotive force and signal indicating device in said local circuit.

16. An oscillation detector comprising an evacuated vessel, two electrodes, one of which is a filament, inclosed within said vessel, means for heating said filament, and a grid of conducting material inclosed within said vessel and interposed between said electrodes.

17. An oscillation detector comprising an evacuated vessel, two electrodes inclosed within said vessel, means for heating one of said electrodes, a conducting member inclosed within said vessel and interposed between said electrodes, and a local circuit including a source of electromotive force connecting said electrodes.

18. An oscillation detector comprising an evacuated vessel, two electrodes inclosed within said vessel, means for heating one of said electrodes, a grid of conducting material inclosed within said vessel and interposed between said electrodes, a local circuit including a source of electromotive force connecting said electrodes and a signal indicating device associated with said local circuit.

19. An oscillation detector comprising an evacuated vessel, two electrodes, one of which is a filament, inclosed within said vessel, means for heating said filament, a grid of conducting material inclosed within said vessel and interposed between said electrodes and a local circuit including a source of electromotive force connecting said electrodes.

20. An oscillation detector comprising an evacuated vessel, two electrodes inclosed therein, means for heating one of said electrodes, a conducting member inclosed within said vessel, a closed oscillation circuit, a circuit connecting one element of said oscillation circuit with one of said electrodes and said conducting member, and a condenser in said circuit.

21. An oscillation detector comprising an evacuated vessel, two electrodes inclosed therein, means for heating one of said electrodes, a conducting member inclosed within said vessel, a closed oscillation circuit, a circuit connecting one element of said oscillation circuit with one of said electrodes and said conducting member, a condenser in said circuit, a signal indicating device and a circuit connecting said device with the other of said electrodes and said conducting member.

In testimony whereof, I have hereunto subscribed my name this 21st day of Dec. 1906.

LEE DE FOREST.

Witnesses:

THOMAS I. GALLAGHER,

HANS W. GOETZE.

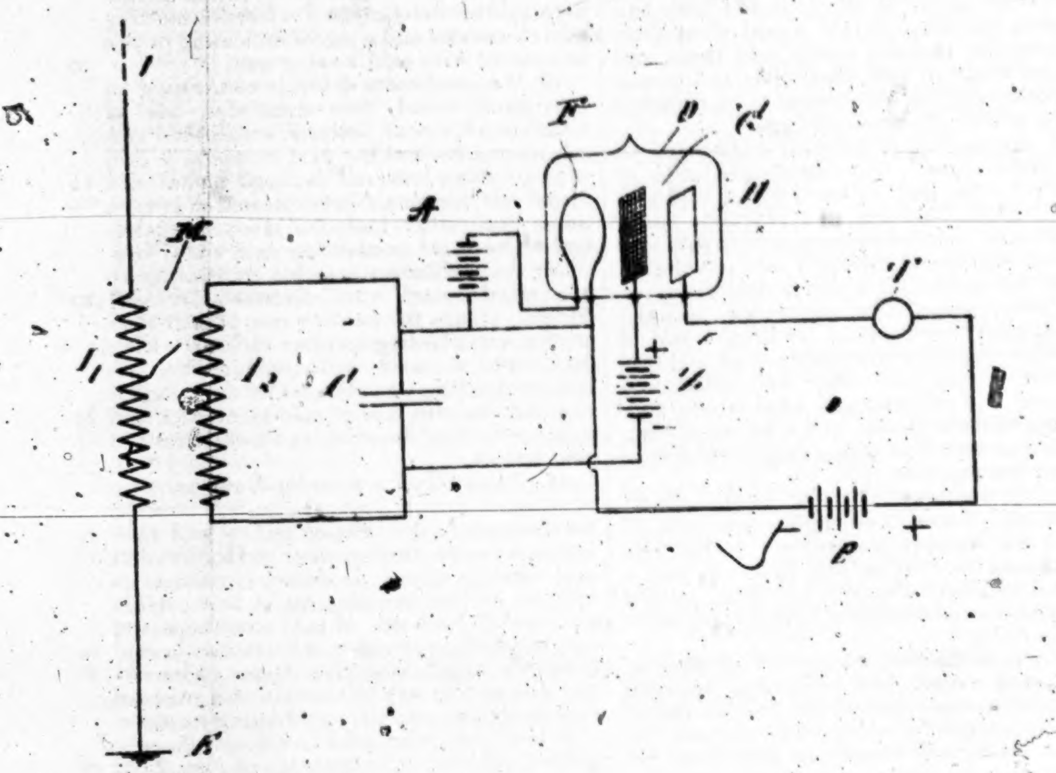
1432

No. 884,110. PATENTED APR. 7, 1908.

J. S. STONE & S. CABOT.

SPACE TELEGRAPHY.

APPLICATION FILED JAN. 4, 1907.



WITNESSES:

E. B. Tomlinson

Patrick J. Conroy

INVENTORS

John Stone Stone

Sewall Cabot

by Brown & Woodworth

Attys.

UNITED STATES PATENT OFFICE.

JOHN STONE STONE, OF BOSTON, AND SEWALL CABOT, OF BROOKLINE, MASSACHUSETTS, ASSIGNORS, BY DIRECT AND MESNE ASSIGNMENTS, TO WILLIAM W. SWAN, TRUSTEE, OF BROOKLINE, MASSACHUSETTS.

SPACE TELEGRAPHY.

No. 884,110. Specification of Letters Patent. Patented April 7, 1908.

Application filed January 4, 1907. Serial No. 350,731.

To all whom it may concern:

Be it known that we, JOHN STONE STONE and SEWALL CABOT, citizens of the United States, and residents, respectively, of Boston and Brookline, in the counties of Suffolk and Norfolk and State of Massachusetts, have invented a new and useful Improvement in Space Telegraphy, of which the following is a specification.

Our invention relates to oscillation detectors for space-telegraph receiving systems, and more especially to the particular oscillation detector known as the audion, a device which is now well known and which has been fully described in a paper by Dr. Lee de Forest published in the *Proceedings of the American Institute of Electrical Engineers*, October, 1906, p. 719, to which reference may be had for a more detailed description thereof than is necessary to set forth herein.

The object of our invention is to improve the sensitiveness of an oscillation detector of the aforesaid type.

Our invention may best be understood by having reference to the drawing which accompanies and forms a part of this specification and which represents in diagram one embodiment of our invention which has given good results in practice.

In the drawing, the figure represents a space telegraph receiving system.

The audion shown in the drawing consists of a vessel D of glass or other suitable material which may be evacuated and in which are included a heated member F, which may be a filament, an electrode H, herein shown as a plate which may be of platinum, and a conducting member G, which may be a grid or screen and which may be interposed between said filament and electrode. The filament F may be heated preferably to incandescence by the battery A or other suitable source of electrical energy. A local circuit connecting the filament F and electrode H includes a telephone T or other suitable signal-indicating device and a source of electromotive force B, the positive terminal of which is connected to the electrode H. The filament F and conducting member G are connected to a closed oscillation circuit, herein shown as the oscillation circuit C I_1 and, as shown, they are connected across the terminals of the condenser C.

V I_1 E is an elevated conductor system including the primary of the transformer M and the circuit C I_1 which includes the secondary of said transformer is made resonant to the frequency of the waves the energy of which is to be received.

We have found that the sensitiveness of the audion, when connected as above described with a closed oscillating circuit is greatly impaired from causes which are somewhat obscure and which we deem it unnecessary to discuss herein. The probable cause is that the conducting member G becomes negatively charged.

We have found that the sensitiveness of the audion may be greatly increased when connected as above described by inserting in the connections of the filament F and conducting member G to the oscillating circuit a source of electromotive force Z having its positive terminal connected to said conducting member and having an electromotive force determined by adjustment with respect to that of the source B which is included in the above mentioned local circuit.

While for the purpose of more clearly disclosing our invention we have described particularly one specific embodiment thereof, it will be understood that many modifications may be made therein without departing from the principle of our invention.

We claim,

1. A space telegraph receiving system having in combination a vessel, a heated member included therein, an electrode included in said vessel, a local circuit connecting said heated member and electrode, a source of electromotive force included in said local circuit and having its positive terminal connected to said electrode, a conducting member included in said vessel, connections from said heated member and conducting member to a closed oscillation circuit, and a source of electromotive force included in said connections and having its positive terminal connected to said conducting member.

2. A space telegraph receiving system having in combination a vessel, a heated member included therein, an electrode included in said vessel, a local circuit connecting said heated member and electrode, a source of electromotive force included in said local circuit and having its positive terminal connected to said electrode, a conducting member sealed within said vessel, connections

from said heated member and conducting member to a closed oscillation circuit, and a source of electromotive force included in said connections and having its positive terminal connected to said conducting member, the electromotive force of the last mentioned source being adjusted with respect to that of the source included in said local circuit.

In testimony whereof, we have hereunto subscribed our names this 1st day of Jan. 1907.

JOHN STONE STONE.
SEWALL CABOT.

Witnesses:
E. B. TOMLINSON,
GEO. K. WOODWORTH.

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PAGE

1435

L. DE FOREST.

SYSTEM FOR AMPLIFYING FEEBLE ELECTRIC CURRENTS.

APPLICATION FILED JUNE 20, 1907.

995,126. Patented June 13, 1911.

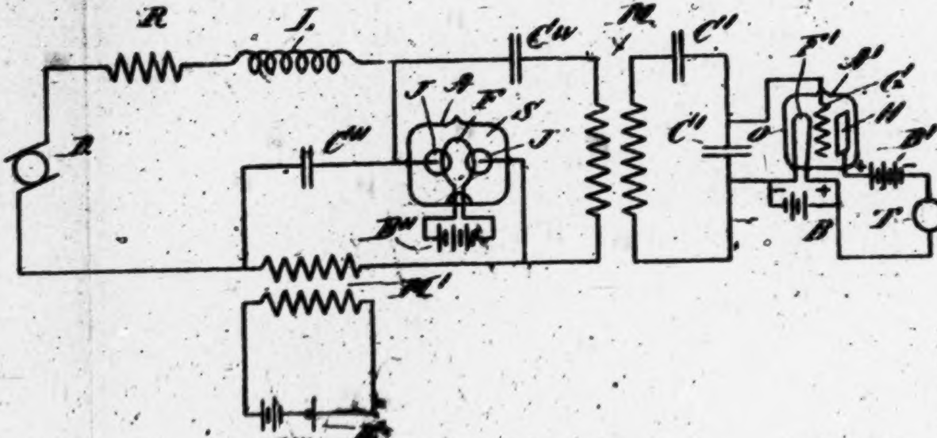

Fig-1.

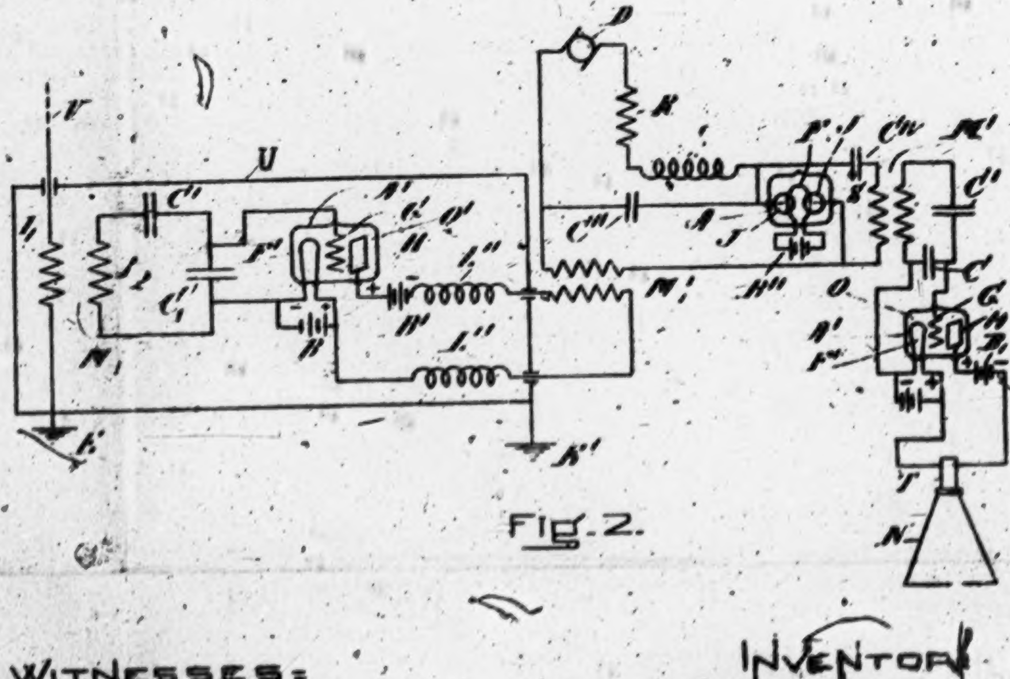

Fig-2.

WITNESSES:

Patrick J. Conroy

George A. Higgins

INVENTOR

Lee de Forest

by [illegible] Woodworth

UNITED STATES PATENT OFFICE.

LEE DE FOREST, OF NEW YORK, N. Y., ASSIGNOR TO DE FOREST RADIO TELEPHONE CO., A CORPORATION OF NEW YORK.

SYSTEM FOR AMPLIFYING FEEBLE ELECTRIC CURRENTS.

995,126. Specification of Letters Patent. Patented June 13, 1911.

Application filed June 20, 1907. Serial No. 379,934.

To all whom it may concern:

Be it known that I, LEE DE FOREST, a citizen of the United States, and a resident of New York, in the county of New York and State of New York, have invented a new and useful Improvement in Systems for Amplifying Feeble Electric Currents, of which the following is a specification.

The present invention relates to systems for amplifying feeble electric currents and its object is to provide such system capable of use in wire telephone or telegraph lines and in space telegraph or space telephone systems.

My invention consists essentially in the interposition between the currents to be amplified and the signal indicating device of a source of high frequency electrical oscillations, hereinafter more fully described, and between said source of electrical oscillations and said signal indicating device I may interpose a circuit including an oscillation responsive device.

The drawings which accompany and form a part of this specification illustrate conventionally several arrangements of apparatus and circuits whereby the above mentioned object has been realized in practice; but it will be understood that I do not limit myself to the precise arrangements shown inasmuch as many modifications may be made therein without departing from the principle of my invention.

In the drawings: Figure 1 represents one form of my invention applied to a wire telephone system. Fig. 2 is a diagram representing the present invention applied to a space telegraph or telephone receiving system.

In the figures, D is a source of direct current, R is a resistance, inductive or non-inductive, L represents an inductance which may be employed, C, C′ C″ C‴ C^{v} are condensers, M M′ M, M,′ are transformers, B B′ B″ B‴ are batteries, K is a microphone transmitter, N is a megaphone, and T is a signal-indicating device which may be a telephone receiver.

In Fig. 1, the circuit S C^{v} M and in Fig. 2 the circuit S C^{v} M^{1}, represents a source of high frequency electrical oscillations having a spark frequency higher than the more essential frequencies accompanying speech waves and preferably higher than the limit instance said circuit is shown as a "singing-arc" circuit capable of developing practically continuous electrical oscillations when it is connected with the source of direct current D through leads of high resistance or high inductance.

In Figs. 1 and 2 I have represented the discharger for the condenser C^{v} as consisting of two electrodes J J sealed in a receptacle A and maintained in any suitable atmosphere under small or large pressure. The filament F may be heated by the current of the battery B^{11}. It will be understood however that I do not limit myself to any special type of discharger and that any suitable source of high frequency oscillations having the characteristics above set forth may be substituted for the circuit S C^{v} M^{1}, or S C^{v} M.

O represents an oscillation detector of any suitable type and herein shown as an audion consisting of the evacuated vessel A′ having sealed therein the filament F′ heated by the battery B, the grid G and the plate H, the latter being connected to the positive pole of the battery B′ and with the signal indicating device T. The audion O is associated in any suitable manner with the tuned circuit M C^{1} C^{1}, which in turn is associated with the source of high frequency oscillations. In the present instance said tuned circuit is shown as inductively related to the circuit S C^{v} M by means of the oscillation transformer M, although any other associating means may be employed.

In Fig. 2 V represents a receiving antenna connected to earth E through the primary I$_1$ of the oscillation transformer M, whose secondary I, forms part of the tuned receiving circuit which includes the condensers C^{1}, C$_1$. Associated with said tuned receiving circuit in any suitable manner is the audion or other suitable oscillation detector O′, the local circuit of which includes the primary of the transformer M′, and if desired, the choke-coils L″ L″.

The telephone circuit and the local circuit of the audion O′ are shown in Figs. 1 and 2 respectively as associated with the high frequency oscillation circuit by means of the transformers M′ M′$_1$, although it will be understood that any other suitable means may be employed to associate the circuit which carries the currents to be amplified

more that I do not limit myself to the association of the said circuits with said oscillation circuit at the particular point shown in Figs. 1 and 2, viz., a point in the leads to said oscillation circuit. When the circuits are arranged in the manner shown in Figs. 1 and 2, the condenser C″ may be employed to afford a path of low impedance for the currents developed in the transformers M′, M′₁. Preferably, the inductive relation of the turned circuits M C⁴ C⁵ with the oscillation circuit should be maintained by a transformer of small magnetic leakage, if a transformer is employed.

In Fig. 2, U represents a metallic case which may be grounded at E E′.

The operation is as follows: The feeble electrical currents developed in the primary of the transformer M′ or M′₁ are impressed upon the high frequency oscillation circuit, thereby varying the amplitude of the oscillations in said circuit in accordance with the sounds initiating said feeble currents. The energy of said oscillations, so varied in amplitude, is transmitted to the circuit M C⁴ C⁵, attuned to the frequency of said oscillations, and actuates the oscillation responsive device O causing thereby currents in the circuit of the telephone T closely approximating in form those developed in the primary of the transformer M′ or M′₁ but greatly exceeding the latter in amplitude. It has been found that the tuned receiving circuit M C⁴ C⁵ need not be employed and also that the oscillation detector O may be omitted as shown in Fig. 3. In this case the telephone receiver T responds to variations in the amplitude of the currents developed in the line Q Q, the frequency of said currents exceeding that to which the diaphragm of said telephone responds.

I claim:

1. The combination with a circuit carrying feeble electric currents of a source of practically-continuous electrical oscillations associated with said circuit, and including arc electrodes, with capacity and inductance in series shunt thereto, an oscillation responsive device, a circuit attuned to the frequency of said electrical oscillations interposed between said source and said oscillation responsive device, and a local circuit including therein a signal indicating device and a source of electro-motive force, associated with said oscillation responsive device.

2. The combination with a circuit carrying feeble electric currents of a source of practically-continuous electrical oscillations associated with said circuit and including arc electrodes with capacity and inductance in series shunt thereto, an oscillation responsive device, a circuit attuned to the frequency of said electrical oscillations interposed between said source and said oscillation responsive device, a local circuit including therein a signal indicating device associated with said oscillation responsive device, and a source of electromotive force in circuit with said signal indicating device.

3. The combination with a circuit carrying feeble electric currents of a source of practically-continuous electrical oscillations associated with said circuit, said source comprising a singing-arc circuit provided with inclosed arc-electrodes, an audion associated with said singing-arc circuit, and a local circuit including a telephone receiver and a source of electromotive force associated with said audion.

4. The combination with a circuit carrying feeble electric currents of a source of high frequency electrical oscillations having a frequency higher than the more essential frequencies accompanying speech waves, an oscillation responsive device associated with said source of electrical oscillations and a signal-indicating device associated with said oscillation responsive device.

In testimony whereof, I have hereunto subscribed my name this 17th day of June 1907.

LEE DE FOREST.

Witnesses:

THOMAS I. GALLAGHER,

ROSCOE KENT.

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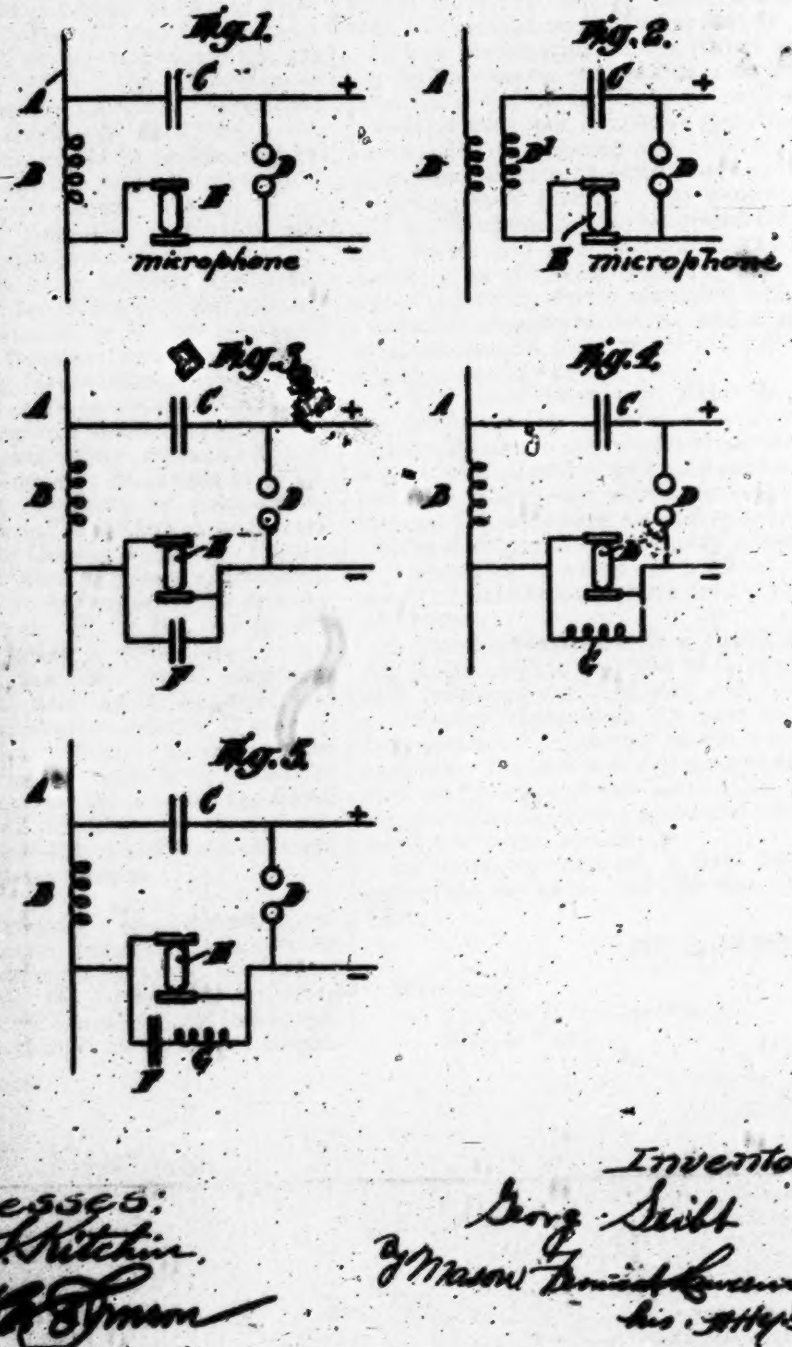
PAGE

1438

G. SEIBT.
RADIO-TELEPHONY.
APPLICATION FILED DEC. 20, 1907.

1,012,456. Patented Dec. 19, 1911.



Witnesses:
A. L. Kitchin.
[illegible]

Inventor
Georg Seibt
By Mason Fenwick & Lawrence
his Attys.

UNITED STATES PATENT OFFICE.

GEORG SEIBT, OF BERLIN, GERMANY, ASSIGNOR TO THE AMALGAMATED RADIO-TELEGRAPH COMPANY, LIMITED, OF LONDON, ENGLAND.

RADIO-TELEPHONY.

1,012,456. Specification of Letters Patent. Patented Dec. 19, 1911,

Application filed December 20, 1907. Serial No. 407,287.

To all whom it may concern:

Be it known that I, Georg Seibt, a subject of the Emperor of Germany, residing at 18 Mathieustrasse, Berlin, in the Empire of Germany, have invented certain new and useful Improvements Relating to Radio-Telephony, of which the following is a specification.

This invention relates to radio-telephony, the chief object being to increase the efficiency of working of radio-telephonic systems.

It is well known that radio-telephony can be produced by means of electrical oscillations by subjecting the intensity of the oscillations produced by the human voice at the transmitting station to rythmical changes. For this purpose some device is required which will cause either the resistance, the inductance, or the capacity, or any combination of these factors, to vary in accordance with the variations of air pressure which constitute acoustic vibrations. That is to say, the alternate compression and rarefaction of the air must be made to produce corresponding changes in either the amplitude, or the periodicity, of the electrical radiations. The simplest form for such an arrangement is to insert a variable resistance, such as a microphone, directly into the antenna or into a circuit coupled with the antenna. By doing so there arises however the disadvantage—if microphones with any kind of resistance are chosen—that only a very small efficiency can be obtained by changing the vibrations of the air into variations of electrical intensity.

According to the present invention the variable resistance is brought into such relation to the fixed resistances that the variation of pressure produced by the acoustic vibrations causes a maximum variation of radiated electrical energy. In the case in which the oscillations are produced in the antenna itself or transferred to it by loose coupling from a closed oscillation-circuit, and assuming the microphone to be inserted directly into the oscillation circuit, theory shows that the resistance of the microphone ought to be numerically equal to the other resistances of the antenna, or in other words, that the damping produced by the microphone antenna itself. This is shown by the following consideration of an antenna excited by a loosely coupled closed oscillation circuit:—Let e represent the E. M. F. induced in the antenna, J the strength of the current, w_m the resistance of the microphone, and w the effective alternating current resistance of the antenna. Then, while having resonance, the strength of current is given by the following equation:—

$$J = \frac{e}{w+w_m}$$

If the resistance of the microphone is, owing to sound waves falling upon the microphone block or plate, varied by an amount Δw_m, J will be increased or diminished by an amount ΔJ. The value of ΔJ is given by the equation:—

$$\Delta J = \frac{e}{w+w_m+\Delta w_m} - \frac{e}{w+w_m}$$

Therefore, assuming $(w+w_m+\Delta w_m)$ differs from $(w+w_m)$ by a negligible amount.

$$\Delta J = \frac{e\Delta w_m}{(w+w_m)^2}$$

If the resistance is only changed slightly as for instance by speaking, the value Δw_m will generally be proportional to the strength of the sound wave and will also be proportional to the resistance of the microphone itself. If the intensity of the sound is kept constant, the microphone having double the resistance of another one which is equivalent to the first in regard to its efficiency will suffer the double variation in resistance. Therefore it can be said that:—

$$\Delta w_m = K w_m$$

where K depends upon the intensity of the sound but not upon the resistance of the microphone. Substituting this value for Δw_m the equation becomes:—

$$\Delta J = \frac{eKw_m}{(w+w_m)^2}$$

It is important for radio-telephony that ΔJ becomes a maximum. Now ΔJ is a maximum or minimum when

By differentiating $\triangle J$ with respect to w_m and equating to zero we obtain:—

$$\frac{d\triangle J}{dw_m}=\frac{eK(w+w_m)^2-2(w+w_m)(eKw_m)}{(w+w_m)^4}=\frac{eKw^2-eKw_m^2}{(w+w_m)^4}=o$$

Therefore $w=w_m$. Also

$$\frac{d^2\triangle J}{dw_m^2}=\frac{-2ekw_m(w+w_m)^4-4(w+w_m)^3(ekw^2-ekw_m^2)}{(w+w_m)^8}$$

and this being a negative quantity shows that the condition $w=w_m$ makes $\triangle J$ a maximum. Hence the condition for maximum efficiency is that the resistance of the microphone and of the system to which it is connected should be equal.

In the accompanying drawings, Figure 1 shows diagrammatically one method of carrying out my invention. Fig. 2 shows the antenna inductively coupled with an associated circuit. Fig. 3 shows the use of capacity in parallel with the variable resistance. Fig. 4 shows an inductance in parallel with such variable resistance. Fig. 5 shows capacity and inductance in series with each other and in parallel with the variable resistance.

A simple arrangement is shown in Fig. 1 of the accompanying drawings, in which A is the antenna, B an inductance, C a condenser, D the source of electrical oscillations, and E the microphone; the resistance of this microphone is equal to that of the system to which it is connected. Fig. 2 is similar to Fig. 1 with the exception that the antenna is inductively coupled to the oscillation circuit by means of the oscillation transformer B B'.

If the resistance of the microphone does not satisfy the above stated condition, its excess or lack of resistance may be compensated for; when the microphone has too high a resistance we may connect a condenser F or an inductance G of determined value in parallel with it as shown in Figs. 3 and 4 respectively; the effect of such a shunt circuit being to take part of the current and thus compensate for too high a resistance of the microphone alone. When the microphone has too low a resistance, a condenser and an inductance in series may be placed in parallel with it as shown in Fig. 5. The condenser and inductance in series connected across the microphone constitute an oscillatory circuit, which if adjusted out of tune with the received oscillations would tend to damp them, and in this way compensate for too low a resistance of the microphone alone. The same may be done when the microphone, instead of being inserted into the antenna, is inserted into a closed circuit loosely coupled with the antenna as it is in Fig. 2. In the case of a shunt circuit being employed with the microphone, the damping due to the microphone and shunt circuit in combination should be equal to the damping due to the resistance of the rest of the system comprising the antenna. When the antenna is coupled rigidly to the oscillation-circuit there will be different relations between the proportion of the resistance of the microphone and the other resistances of the oscillation circuits on account of the circuits affecting each other mutually. But it is always desirable, even if the maximum were not very sharp, to keep the amount of energy consumed by the microphone equal or nearly equal to the energy spent in the system to which it is connected.

What I claim and desire to secure by Letters Patent of the United States is:—

1. In a system of radio-telephony in which the transmitting apparatus comprises means for producing and transmitting electrical oscillations, and means comprising an ohmic resistance which coöperates with the first mentioned means and is capable of causing variations in intensity of the electrical oscillations by amounts corresponding to the variations of acoustic vibration produced by speaking; means for relatively adjusting the aforesaid ohmic resistance and the resistance of the system with which it coöperates until they are approximately equal.

2. In a system of radio-telephony in which the transmitting apparatus comprises means for producing and transmitting electrical oscillations, and means comprising electrical resistance coöperating with the first mentioned means for varying the electrical oscillations by amounts corresponding to variations of acoustic vibrations produced by speaking, means contained in a circuit shunted from the said electrical resistance for making the damping effect of the latter and of the shunt circuit in combination equal to that due to the resistance of the system to which they are connected.

In testimony whereof I affix my signature in presence of two witnesses.

GEORG SEIBT.

Witnesses:

WOLDEMAR HAUPT,

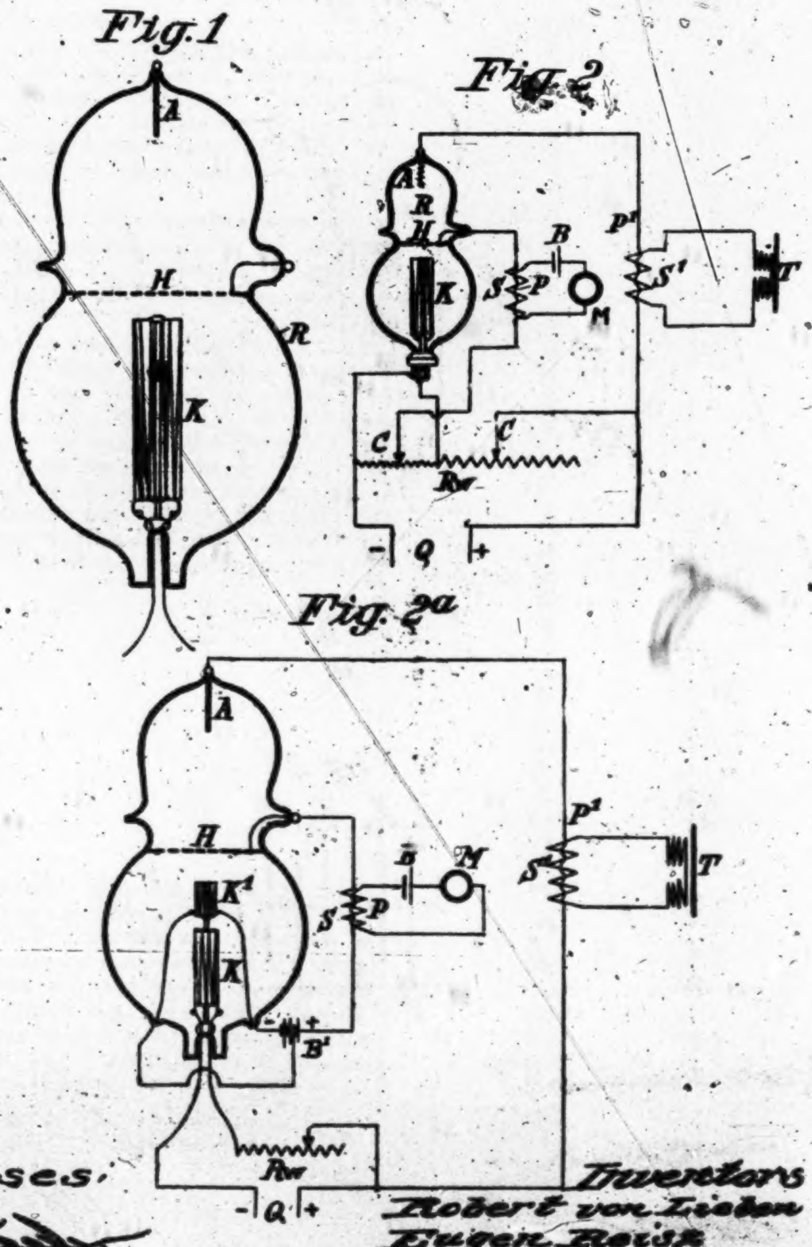
ARTHUR SCHROEDER.

1441

R. VON LIEBEN & E. REISZ.
RELAY FOR UNDULATORY CURRENTS.
APPLICATION FILED JAN. 20, 1911.

1,038,910.

Patented Sept. 17, 1912.
2 SHEETS—SHEET 1.



Witnesses:

Inventors
Robert von Lieben
Eugen Reisz
by

1442

R. VON LIEBEN & E. REISZ.
RELAY FOR UNDULATORY CURRENTS.
APPLICATION FILED JAN. 30, 1911.

1,038,910. Patented Sept. 17, 1912.

2 SHEETS—SHEET 2.

Fig. 3

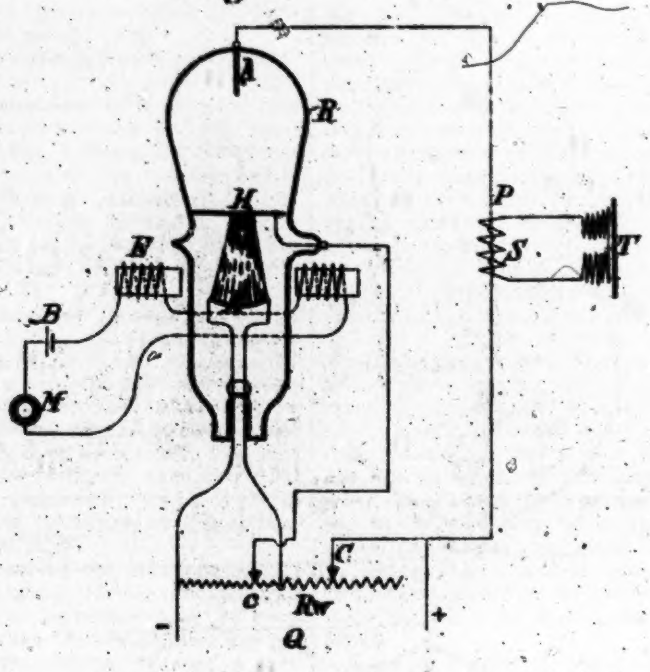
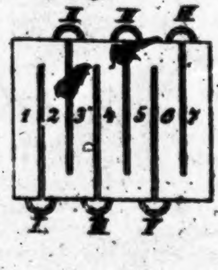


Fig. 3a



Witnesses:

Inventors
Robert von Lieben
Eugen Reisz
by

UNITED STATES PATENT OFFICE.

ROBERT von LIEBEN AND EUGEN REISZ, OF VIENNA, AUSTRIA-HUNGARY, ASSIGNORS OF ONE-THIRD TO SIGMUND STRAUSS, OF VIENNA, AUSTRIA-HUNGARY.

RELAY FOR UNDULATORY CURRENTS.

1,038,910. Specification of Letters Patent. Patented Sept. 17, 1912.

Application filed January [illegible], 1911. Serial No. [illegible].

REISSUED

To all whom it may concern:

Be it known that we, ROBERT VON LIEBEN and EUGEN REISZ, subjects of the Emperor of Austria-Hungary, residing at Vienna, Austria-Hungary, have invented certain new and useful Improvements in Relays for Undulatory Currents, of which the following is a specification.

This invention relates to improvements in undulatory current relays, and the primary object of the same is to reinforce current waves of the most varied frequency and form.

The invention as hereinafter disclosed and illustrated in the drawings constitutes an improvement on that disclosed in our copending application Serial No. 605,547, wherein by means of varying the ionization of the space between the electrodes, as for instance by means of cathode rays, the resistance of the circuit connected to the electrodes is altered so that the current waves introduced will produce proportionate variations.

The subject of the present invention is a further development of the above mentioned invention, wherein instead of being altered indirectly by means of an ionizer the resistance in the main circuit is altered directly by means of an auxiliary electrode, on which the currents to be reinforced act. For this purpose the auxiliary electrode, which is likewise made of grid or net form, is arranged in such a manner that it completely intersects or divides the space between the cathode and anode in the discharge tube; moreover, it is connected with a source of direct current in such a manner that it has an exactly defined potential corresponding to the degree of reinforcement required for the time being. In order to enable this potential to be adjusted as required, an adjustable resistance is preferably introduced between the electrode and the source of electric current. By this means the valve-like action of the incandescent electrode is dispensed with, since the alternating current to be reinforced is superposed on a constant direct current, whereby an undulatory current is formed from the alternating current. [illegible] the presence of the constant potential of the electrode, the magnitude of which is suitably chosen between that of the cathode and that of the anode, causes the formation of an artificial dark space near the cathode and thus of a space where the number of ions is small, around the apertures of the auxiliary electrode toward the anode, whereby again the resistance of the main circuit, which is just what it is desired to alter, is considerably increased. This displacement of the maximum drop of potential into proximity to and into the openings of the auxiliary electrode and also the circumstance that this grid-electrode entirely fills up the cross-section of the discharge tube, permit the employment of currents which are practically of any desired strength, since here the formation of an arc outside the grid is rendered impossible and the formation of an arc in the apertures of the grid is rendered very difficult by the production of the artificial dark space near said apertures.

The openings or contractions, as is known, form a virtual resistance for the gas discharge, which resistance, however, as we have discovered, can be very considerably altered if, between the cathode and the partition-wall, a constant but regulable voltage be applied; and it appears that even with a very slight increase or reduction of the potential-difference, the resistance or back electromotive force in the discharge tube will be smaller or greater. The currents to be reinforced now alter the resistance of the auxiliary electrode, whereby the currents passing between the cathode and anode are altered in proportion to this resistance.

The drawings show by way of example some constructional forms of the subject of the application.

In these drawings: Figure 1 is a section of the discharge tube. Fig. 2 is a diagram of the connections of the relay. Fig. 2ª shows a further constructional form of the relay with an auxiliary cathode. Fig. 3 shows a further constructional form of the subject of the application, wherein another method of altering the resistance of the auxiliary electrode is employed. Fig. 3ª is a development of the cathode belonging thereto.

In Fig. 1 the cathode K is arranged in the discharge tube R. This cathode is preferably an incandescent metallic oxid cathode (a Wehnelt cathode) and has the form of incandescent metal bands covered with metallic oxids, which bands are wound on a carrier or support in a similar manner

to that in which metal filament lamps are constructed. This construction of the cathode has the advantage that the irregularly distributed cathode rays emitted by the incandescent bands (filaments) do not strike the auxiliary electrode directly whereby the current density is uniformly distributed over the auxiliary electrode. H is the said auxiliary electrode, which divides or intersects the space between the cathode K and the anode A and is preferably made in the form of wire gauze or netting or perforated sheet metal or as a combination of the two.

The cathode K, in combination with a regulating resistance Rw (Fig. 2) which regulates the temperature of the incandescent metal bands, is connected to the source of direct current Q. The anode A is connected to the positive pole of the said source of current through the primary winding P'. To the regulating resistance Rw is further connected at *c* the auxiliary electrode H through the secondary winding of a second transformer. As shown in Fig. 2, the microphone circuit BM acts inductively on the gas current between K and H through the primary winding P. The voltage which exists between the cathode K and the auxiliary electrode H, is given by the adjustment of the contact *c* of the regulating resistance Rw. This application of a regulable pressure has been found to be an extremely important expedient for the sensitiveness of the relay, since a proportionally strong alteration of resistance in the gas discharge tube only occurs with a quite definite value of the voltage and this depends on the pressure of the gas in the tube, the temperature of the electrode, etc. It was further established by experiment that with greater strengths of the current and more especially with such strengths as first render the relay practically useful, the auxiliary electrode H, as above mentioned, must entirely shut off the cross-section of the tube, since otherwise shunting of the gas-current would occur, which almost entirely destroys the action of the relay.

The method of operation of the relay is as follows: The currents from the microphone circuit superposed inductively on the circuit between K and H through the transformer PS alter the back electromotive force or resistance of the gas discharge tube, so that the main current passing through the anode A acts through the second transformer P' S' on the telephone T. As already set forth, with a definite difference of potentials between K and H, which can be adjusted by means of the sliding contact *c*, the resistance of the gas discharge produced by the auxiliary electrode is extremely sensitive and the small variations of potential caused by the variations of resistance of the microphone are therefore sufficient to alter the strength of the current in the discharge tube very considerably, so that a powerful relay action is obtained.

In Fig. 2ª a second cathode K' is provided, which is connected to a separate source of current B', and to the positive pole of which the electrode H is connected through the transformer. Since in this system of connections the temperature of the cathode K' can be made independent of the cathode K, the drop of potential at the cathode K' can be very considerably reduced by a correspondingly high temperature of the bands at K' and consequently the variations of current of the transformer PS increased, without the main current flowing to the anode in the discharge tube being considerably increased. The temperature of the main cathode and therefore the current flowing through the anode A cannot be increased indefinitely, since at a critical value of the current determined by the cross-section of the tube the sensitiveness of the relay again decreases.

Another form of construction of the relay is shown in Fig. 3. In this, the cathode K is made in the form of a concave mirror, in order to unite the rays emitted thereby into one pencil; H is the auxiliary electrode, which is again arranged as a partition-wall between the cathode and anode and has an opening or window, provided with a perforated metal sheet or wire gauze forming a grid. The anode A is connected in a known manner to the positive pole of Q. The pair of electromagnets E is connected in series with the microphone M and a battery. In the opening or window of the auxiliary electrode H is mounted a piece of perforated sheet metal, a grid or a combination of the two, in order to increase the back electromotive force or rather the main resistance to be altered of the tube between K and A. The regulating resistance Rw with the contacts *c* and C is connected as in the form shown in Fig. 2. The alterations of current in the microphone circuit cause the pencil of rays to be deflected, whereby the apertures in the window of the auxiliary electrode H, to which a constant direct current potential can be applied, are more or less struck by the pencil of cathode rays and are therefore subjected to an ionization of varying intensity. By this means the back electromotive force or the resistance in the main circuit between K and A is altered according to the variations of current in the primary. The back electromotive force or resistance in the discharge tube increases when the pencil of rays is deflected from the opening and decreases when the pencil of rays strikes the opening or window. The concave mirror cathode is preferably made in such a manner that in order to avoid too high currents for the

heating thereof, the conductor is arranged in zigzag form and the several strips are mechanically supported relatively to each other by fire-proof bridge-pieces *e. g.*, of glass or porcelain, as shown by way of example in Fig. 3ª, in which the transverse members of the zigzag conductor produced by slotting a sheet of platinum alternately on opposite sides are marked 1, 2, 3, and the glass bridge-pieces I, II, III.

For both arrangements experiments have shown that for the proportional reproduction of alternating currents, the openings in the partition-wall must be made of different sizes.

The above described relay for undulating currents can be employed for strengthening sound, as a relay in overhead wire and cable telephony in short and long distance communication, also in wireless telegraphy and telephony, as an auxiliary apparatus for the telegraphone and as a cell sensitive to light for the electric transmission of pictures, etc.

What is claimed is:

1. A relay for undulatory currents comprising a discharge tube, a cathode and an anode therein, an auxiliary electrode to cause a drop of potential between the cathode and anode and formed with apertures and intersecting the space in the discharge tube between said cathode and anode and dividing it into separate parts, and a source of direct current connected to said auxiliary electrode.

2. A relay for undulatory currents comprising a discharge tube, a cathode and an anode therein embodied in an electric circuit with said cathode, an auxiliary electrode formed with apertures and intersecting the space between the cathode and the anode, a source of direct current connected to said auxiliary electrode, the latter forming a resistance for the currents in the circuit, and means for varying said resistance in accordance with the currents to be reinforced.

3. In a relay for undulatory currents, an exhausted discharge tube, a cathode and an anode therein, embodied in an electric circuit, a grid-like auxiliary electrode intersecting the discharge tube between the cathode and the anode and dividing it into separate parts, a source of direct current connected to the auxiliary electrode, the latter forming a resistance for the currents in the circuit, an adjustable resistance between said source of direct current and the auxiliary electrode, and means for varying the resistance of said electrode in accordance with the currents to be reinforced.

4. In a relay for undulatory currents, an exhausted discharge tube, a cathode of metallic oxid filaments heated to incandescence, the filaments being wound on a carrier in the manner of a metal filament lamp, an anode embodied in an electric circuit with said cathode, a grid-like auxiliary electrode intersecting the space of the discharge tube and dividing it into separate parts, this electrode being perpendicular to the axis of the carrier, a source of direct current connected to said electrode, the latter thus forming a resistance for the currents in the circuit, an adjustable resistance between the source of direct current and the electrode, and means for varying the resistance of said electrode in accordance with the currents to be reinforced.

5. In a relay for undulatory currents, an exhausted discharge tube, a cathode and an anode therein embodied in an electric circuit, a grid-like auxiliary electrode intersecting the discharge tube between the cathode and the anode and dividing it into separate parts, a source of direct current connected to the auxiliary electrode, an adjustable resistance in the circuit between the source of direct current and the auxiliary electrode, and means to superpose the undulating currents to be reinforced on said circuit.

6. In a relay for undulatory currents, an exhausted discharge tube, a cathode and an anode therein embodied in an electric circuit, an auxiliary cathode embodied in a separate circuit, a grid-like auxiliary electrode intersecting the discharge tube between the auxiliary cathode and the anode and dividing it into separate parts, a source of direct current connected to the auxiliary electrode and the circuit of the auxiliary cathode, and means to superpose the undulating currents to be reinforced on the circuit of the direct current source.

In testimony whereof we have hereunto set our hands in presence of two subscribing witnesses.

ROBERT von LIEBEN.
EUGEN REISZ.

Witnesses:
Josef Rubasch,
August Fugger.

1446

H. DE F. ARNOLD.
ELECTRIC RELAY.
APPLICATION FILED MAY 16, 1914.

1,114,845. Patented Oct. 27, 1914.

Fig. 1.

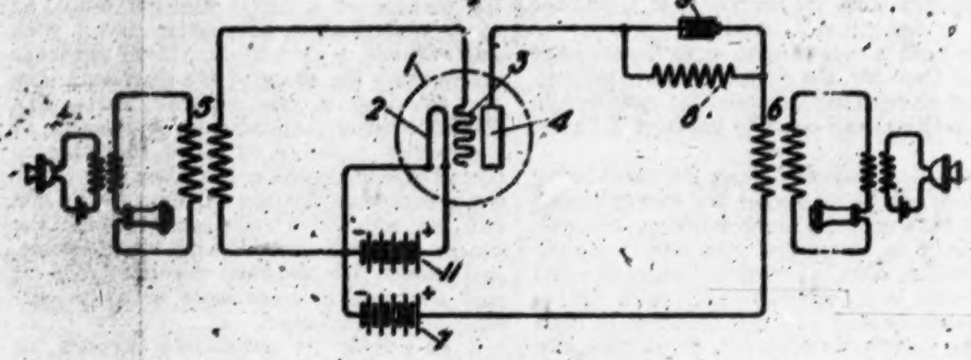


Fig. 2.

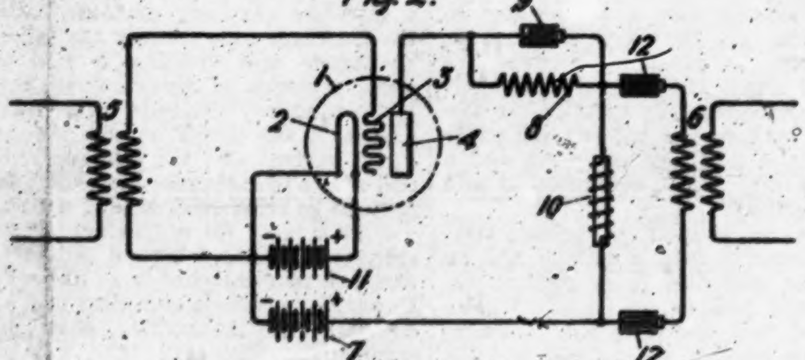
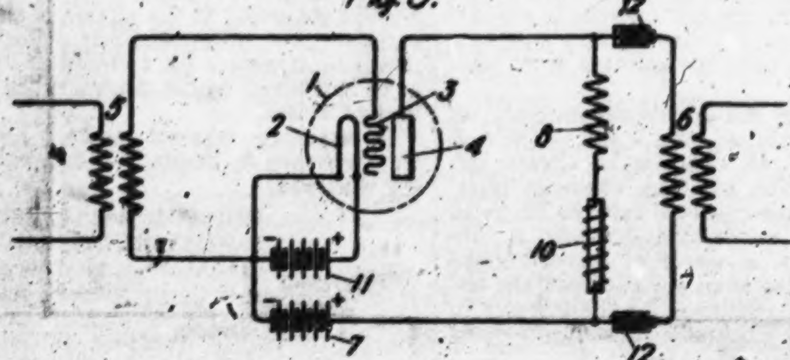


Fig. 3.



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UNITED STATES PATENT OFFICE.

HAROLD DE FOREST ARNOLD, OF EAST ORANGE, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, OF NEW YORK, N. Y., A CORPORATION OF ILLINOIS.

ELECTRIC RELAY.

1,114,845. Specification of Letters Patent. Patented Oct. 27, 1914.

Application filed May 16, 1914. Serial No. [illegible].

To all whom it may concern:

Be it known that I, HAROLD DE FOREST ARNOLD, a citizen of the United States, residing at East Orange, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Electric Relays, of which the following is a full, clear, concise, and exact description.

This invention relates to devices for amplifying feeble impulses of electrical energy, and more particularly to the audion as a repeater.

It has been found in the usual audion structure that when energies of considerable magnitude, such, for instance, as are encountered in ordinary telephone systems, are impressed upon the input circuit of the audion, a blue haze appears in the bulb of the audion. This blue haze may be produced in the bulb either by raising the potential of the battery in the output circuit of the audion to an excessive value, or it may be produced by an increase in potential beyond a certain value between the grid and the filament. When the blue haze is present, the audion becomes inert and ceases to function as an amplifier. For instance, when used as a telephone relay, the transmission ceases almost entirely when the blue haze appears. It has been found experimentally that the establishment of the condition of discharge described above as the blue haze may be prevented by placing, in series with the battery, a balancing resistance of such high value that the increase in current which would normally take place when the condition in the bulb corresponding to the blue haze exists, results in such an increase in fall of potential across the resistance as to render the maintenance of the condition corresponding to blue haze impossible.

In the accompanying drawing,—Figure 1 is a diagram illustrating one embodiment of the invention; and Figs. 2 and 3 are diagrams illustrating slight modifications of the system.

Like reference characters refer to like parts throughout the several views.

In said figures, the evacuated vessel 1 is provided as usual with a heated filament 2, a grid 3 and a plate 4. This device is well known in the art and is termed an audion. The input circuit of the audion includes the secondary coil of a transformer 5, the grid 3 and the filament 2. The output circuit of the audion includes the plate 4, the primary coil of a transformer 6, the filament 2 and the battery 7. In accordance with this invention, there is included in this output circuit a balancing resistance 8. In Fig. 1, the resistance 8 is shown as connected in series with the primary winding of the transformer 6, a condenser 9 being placed in shunt of said resistance in order to permit the passage of fluctuating current.

In Fig. 2 an impedance coil 10 is placed in a bridge of the output circuit, the condensers 12, 12 being provided to prevent the passage of direct current from the battery 7 while at the same time permitting the passage of fluctuating current.

In Fig. 3 the balancing resistance 8 is placed in series with the impedance 10 in a bridge of the output circuit.

The input circuit of the audion is inductively connected with the incoming line by the transformer 5, and the output circuit of the audion is inductively connected with the outgoing line by the transformer 6. The filament 2 is connected to the opposite poles of a battery 11 in order to maintain said filament in a state of incandescence.

What is claimed is:

In an electric relay, the combination with an audion having an input and an output circuit, said output circuit including a source of direct current, of a balancing resistance in the output circuit in series with said source of direct current and a condenser in shunt of said resistance, said balancing resistance being of such high value that the increase of current which normally takes place when a blue haze exists in the bulb of the audion, results in such an increase in fall of potential across said resistance as to prevent the maintenance of said blue haze.

In witness whereof, I hereunto subscribe my name this 14 day of May, A. D., 1914.

HAROLD DE FOREST ARNOLD.

Witnesses:

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ELLA EDLER.

1448

G. W. PIERCE.

APPARATUS FOR AMPLIFYING OR DETECTING ELECTRICAL VARIATIONS.

APPLICATION FILED MAR. 11, 1914.

1,127,371. Patented Feb. 2, 1915.

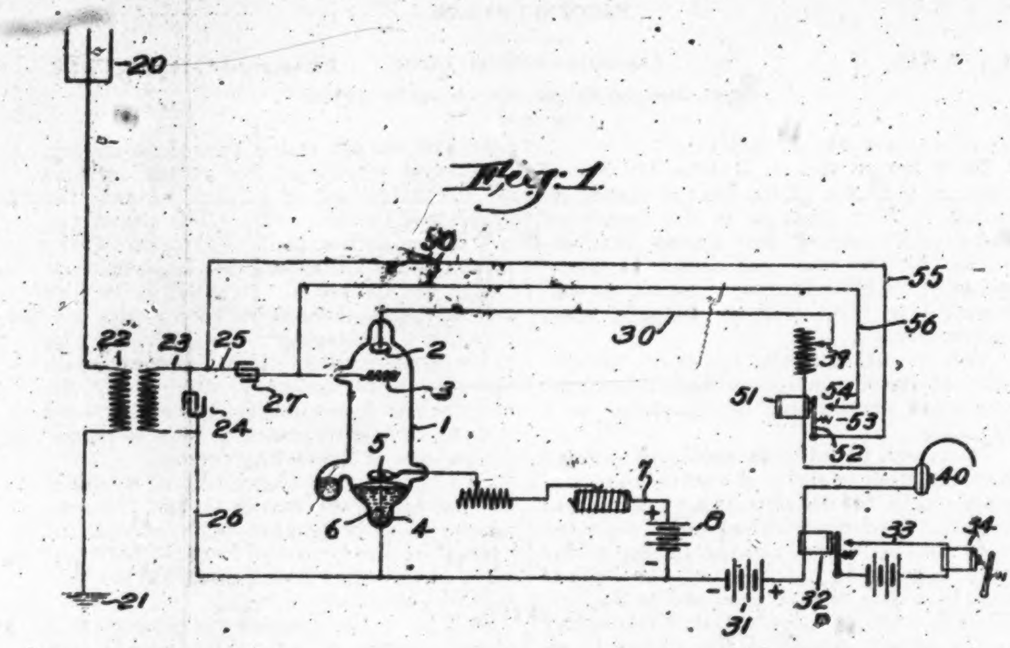

Fig: 1.

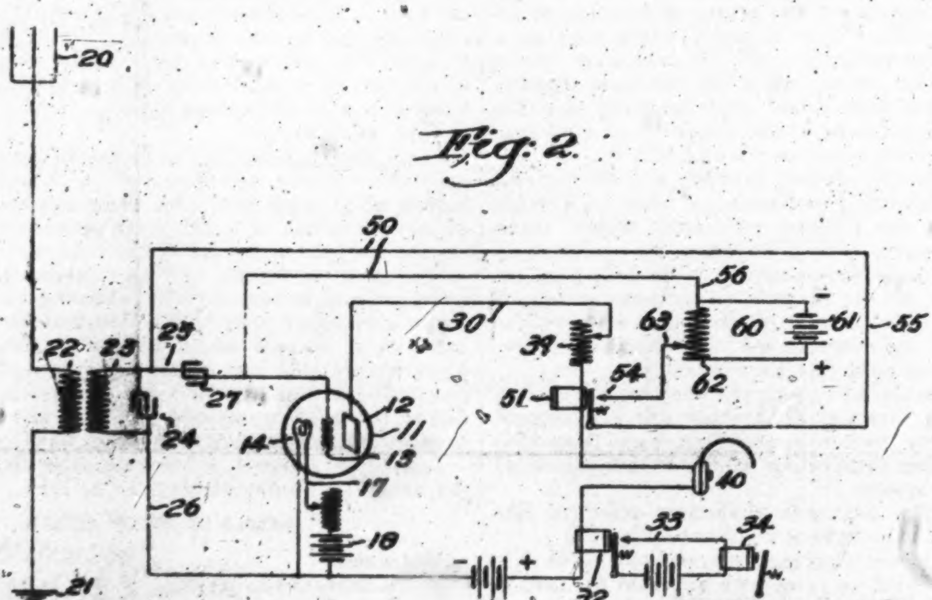

Fig: 2.

Witnesses,
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Alice Ackroyd

Inventor:
George W. Pierce
by his attorneys
Phillips, Van Everen & Fish

UNITED STATES PATENT OFFICE.

GEORGE W. PIERCE, OF CAMBRIDGE, MASSACHUSETTS.

APPARATUS FOR AMPLIFYING OR DETECTING ELECTRICAL VARIATIONS.

1,127,371. Specification of Letters Patent. Patented Feb. 2, 1915.

Application filed March 11, 1914. Serial No. [illegible].

To all whom it may concern:

Be it known that I, George W. Pierce, a citizen of the United States, residing at Cambridge, in the county of Middlesex and State of Massachusetts, have invented certain new and useful Improvements in Apparatus for Amplifying or Detecting Electrical Variations; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

The present invention relates to an apparatus for amplifying or detecting electrical variations.

In the apparatus illustrated and described in my Patent No. 1,112,655, October 6, 1914, apparatus for receiving or relaying electric signals, and my Patent No. 1,112,549, October 6, 1914, apparatus for amplifying or detecting electrical variations, a body of gas in an evacuated tube is maintained in a sensitive conducting condition by means of an ionizing agency, such as a hot filament or a mercury arc. Associated with the ionizing agency are two electrodes. One electrode serves as an anode and is connected through a controlled circuit to the ionizing agency. The second electrode is an open-work electrode or screen and is interposed between the first electrode and the ionizing agency. The screen is connected by means of a controlling circuit to some point in the controlled circuit, either at the ionizing agency or at the anode. In the controlling circuit is a condenser which serves to insulate the screen from the controlled circuit. When electrical oscillations are impressed upon the controlling circuit, they pass through the condenser and cause oscillations of potential on the screen. There is apparently a rectifying action at the screen so that during the train of oscillations the screen acquires a negative charge. As pointed out in Patent No. 1,112,549, the apparatus is ordinarily adjusted to the intensity of the received impulses so that after the cessation of the train of received oscillations the screen loses its negative charge very rapidly, and the evacuated tube quickly recovers its normal conductivity. It is found however that, when the apparatus is adjusted so that it will be sensitive to feeble received oscillations, if stronger oscillations are impressed on the controlling circuit there will be an appreciable time lag before the tube recovers its normal conductivity. This is believed to be due to an accumulation of a sufficiently great negative charge on the screen and condenser caused by the rectification of the [illegible] oscillations, so that the charge is not dissipated from the screen for an appreciable time.

The apparatus of the present invention is an improvement on the apparatus described in said applications and is so constructed that the evacuated tube quickly recovers its normal conductivity after receiving a train of strong oscillations as well as after receiving a train of weaker oscillations. The present invention is however not limited to the type of detecting apparatus shown in said applications, but may be applied to other types of detecting apparatus in which there are accumulated electric charges which it is desirable to discharge.

In the drawings which illustrate the preferred embodiment of the invention, Figure 1 is a diagrammatic view showing the apparatus of the present invention applied to an evacuated vessel which is ionized by means of mercury arc; and Fig. 2 is a diagrammatic view showing the apparatus of the present invention applied to an evacuated vessel ionized by means of an incandescent filament.

In Fig. 1, the means for maintaining the sensitive conducting gaseous space comprises an evacuated vessel or tube 1 in which are inclosed an electrode 2, an openwork electrode or screen 3, and an ionizing agency which consists of a body of mercury 4 and a perforated arc terminal plate 5. A platinum wire 6 extends through and just projects from the mercury and serves as an arc centering device. The mercury arc is maintained by means of a keep-alive circuit 7 which includes battery 8. This mercury vapor tube is substantially the same as that shown in my Patent No. 1,112,549 and my Patent Number 1,0[illegible].

In Fig. 2, the means for maintaining a sensitive conducting gaseous space comprises an evacuated vessel or tube 11 in which are inclosed an electrode 12, an openwork electrode or screen 13, and an ionizing agency which consists of an incandescent filament 14. The incandescent filament is heated by means of a local circuit 17 which includes a battery 18. The evacuated ves-

sel is substantially the same in arrangement of its parts as the filament ionized evacuated vessels shown in Patent No. 1,112,655.

In both Figs. 1 and 2, 20 indicates the antenna of a wireless receiving system connected to ground at 21. Instead of the antenna circuit illustrated in the drawings, other signal receiving circuits may be employed, such for example, as those indicated in my prior applications referred to above. The antenna circuit is coupled by means of an oscillation transformer 22 to a closed high frequency oscillation circuit 23 which contains a condenser 24. Tapped from the oscillation circuit 23 on the opposite sides of the condenser 24 are receptor leads 25 and 26. The leads 25 and 26 and their connections with the receiving apparatus constitute what may be termed the "controlling" circuit by means of which the electric potential variations set up in the receiving apparatus by the received waves are impressed upon the sensitive conducting gas in the tube. The receptor lead 25 is connected to the open-work electrode or screen. The receptor lead 26 is connected to one of the leading-in wires of the ionizing means, the connection in Fig. 1 being to the platinum wire 6, the connection in Fig. 2 being to one of the wires of the filament-heating circuit 17. This forms a connection from the controlling circuit to the controlled circuit, which is hereinafter described. A condenser 27 is interposed in the controlling circuit, preferably in the lead 25, and serves as a stoppage condenser to insulate the open-work electrode or screen from the controlled circuit. An electric circuit 30, which is designated as the "controlled" circuit is connected between the electrode 2 in Fig. 1 or the electrode 12 in Fig. 2, and the ionizing agency. In the circuit 30 is a battery 31, the positive pole of which is connected to the electrode 2. The electrode 2 and the ionizing agency serve as the anode and cathode electrodes respectively of the controlled circuit 30. The circuit 30 may be provided with a ballast resistance 39. Included in the circuit 30 is a relay 32. The relay 32 operates upon the decrease in current in the circuit 30 to close the sounder circuit 33 and operate the telegraphic sounder 34. When the train of Hertzian waves strikes the antenna, the apparent conductivity of the vapor tube is decreased and cuts down the current in the controlled circuit 30 causing the sounder 34 to operate. The construction and arrangement of the parts just described are substantially the that of Patent No. 1,112,549 and a further detailed description is not necessary. The telephone receiver 40 is also included in the controlled circuit 30 and may be used for audibly detecting received messages which are too faint to operate the relay and sounder. The telephone receiver may be used for detecting all received signals in which case the relay 32 and sounder circuit 33 may be dispensed with.

The device for permitting a rapid recovery of the conductivity of the vapor tube after the reception of a train of strong oscillations, comprises a shunt circuit 50 connected around the condenser 27 and a relay 51 which operates to close the shunt circuit upon a sufficient decrease in the current of the controlled circuit 30. The relay 51 is connected directly in the circuit 30 and operates while the normal current is flowing in the circuit 30 to attract and hold its armature 51. When the current in the circuit 30 drops below a predetermined amount, the relay armature 52 is released and is drawn by its spring 53 against the contact point 54. The armature 52 is connected by one of the lead wires 55 of the shunt circuit 50 to one side of the condenser 27, and the contact point 54 is connected through the other lead wire 56 to the other side of the condenser 27. The moving parts of the relay 51 are light so that they operate very rapidly.

The amount of decrease in current in the controlled circuit 30 is apparently dependent upon the strength of the received oscillations impressed on the open-work electrode or screen. When the received oscillations are comparatively feeble, the vapor tube recovers its normal conductivity rapidly after the cessation of the train of oscillations, and there is therefore no need of discharging any charges accumulating on the open-work electrode or screen. The relay 51 may be inoperative on very weak signals, so that the shunt circuit 50 is not closed upon the comparatively small decrease in current in the controlled circuit 30 incident to the reception of feeble oscillations. The telephone receiver 40 does respond however, to such current decrease. However, when the received oscillations are comparatively strong, there is a greater decrease in the current in the controlled circuit 30 as well as a tendency for the tube to have an appreciable time lag in recovering its conductivity. This tendency is corrected by the relay 51, which short-circuits the condenser 27. When there are impressed on the tube received impulses sufficiently strong to cause an objectionable time lag in the recovery of the tube, the current in the circuit 30 is reduced below a predetermined amount, and the relay 51 operates to close the shunt circuit 50. As soon as the shunt circuit 50 is closed the open-work electrode and the stoppage condenser are discharged and the tube immediately recovers its normal conductivity and the current in the circuit 30 momentarily rises and operates the relay 51 to open the shunt circuit 50, whereupon

the screen accumulates another charge and apparent conductivity of the tube again is lowered until the relay 51 again operates to short-circuit the condenser 27. During the reception of a train of strong oscillations, the relay 51 is continually vibrating. The integrated or average current in the controlled circuit 30 is however sufficiently reduced so that the relay 32 closes the sounder circuit 33. The relay 32 may be slow in operation so that the sounder 34 does not rattle during the reception of a train of strong impulses, but if desired, the relay 32 and sounder 34 may be quick acting and produce an interrupted motion by which the message may be read or recorded.

In Fig. 2, a source of electro-motive force 60 is included in the lead 56 of the shunt circuit 50. The source of electro-motive force 60 includes a battery 61, a resistance 62, with which a movable contact point 63 in the circuit 50 is connected. By adjusting the contact point 63, the electro-motive force impressed on the shunt circuit 50 may be varied. The action of this electro-motive force is to prevent the open-work electrode 13 from being entirely discharged when the condenser 27 is short-circuited through the shunt circuit 50, and consequently prevents the resistance of the tube 11 from being as greatly reduced as is the case when the condenser 27 is short-circuited through a shunt circuit like that in Fig. 1. In some cases it is desirable to use the source of electro-motive force 60 because a greater reduction in the current of the controlled circuit 30 may be had when the relay 51 is operating.

By means of the present invention the apparatus operates to receive strong as well as feeble oscillations. The apparatus is adjusted for the feeble oscillations and then the tendency which the strong impulses would otherwise have to delay the recovery of the tube is automatically prevented by means of the current controlled relay and shunt circuit. This is of particular importance in wireless telegraphy where it may be desirable to pick up successively a number of sending stations, the received oscillations of which vary in intensity.

The available sensitiveness of the receiving apparatus is increased because the apparatus may be adjusted to its maximum sensitiveness for the reception of feeble signal impulses and this adjustment need not be disturbed if the impulses grow stronger or other strong impulses are to be received.

It will be noted that the device for discharging the charges accumulated on the condenser and open-work electrode by the rectifying action of the tube does not operate continuously but is initiated by the received signal impulses and ceases to operate after the received signal impulses cease.

The present invention is not limited in its application to the particular forms and arrangement of the means for maintaining the gaseous conducting space or the connections of the controlling and controlled circuits, neither is the present invention limited to the particular apparatus for securing the quick recovery of the tube, but may be embodied in other constructions within the scope of the invention as pointed out in the following claims:—

I claim—

1. An apparatus for amplifying or detecting electrical variations having, in combination, means for maintaining a sensitive conducting gaseous space, a plurality of electrodes in the space, a controlled electric circuit including a source of electrical energy connected between two of the electrodes, a controlling electric circuit including a condenser connected to an electrode other than the controlled circuit electrodes, and means controlled by the current in the controlled circuit for shunting the condenser.

2. An apparatus for amplifying or detecting electrical variations having, in combination, an evacuated vessel, an electrode in the vessel, an ionizing agency in the vessel, a controlled electric circuit connected between the ionizing agency and the electrode, means for impressing an electromotive force on the controlled circuit, a second electrode in the vessel, a controlling electric circuit connected with the second electrode and including a condenser, and means controlled by the current in the controlled circuit for shunting the condenser.

3. An apparatus for amplifying or detecting electrical variations having, in combination, means for maintaining a sensitive conducting gaseous space, a plurality of electrodes in the space, a controlled electric circuit connected between two of the electrodes, means for from time to time temporarily varying the apparent conductivity of the space including a controlling circuit connected to an electrode other than the controlled circuit electrodes, and means controlled by the current in the controlled circuit for discharging charges accumulated on the controlling circuit electrode.

4. An apparatus for amplifying or detecting electrical variations having, in combination, an evacuated vessel, an electrode in the vessel, an ionizing agency in the vessel, a controlled electric circuit connected between the ionizing agency and the electrode, means for impressing an electromotive force on the controlled circuit, means for varying the apparent conductivity of the space between the ionizing agency and the first electrode including a second electrode in the vessel and a controlling circuit connected between the second electrode and

the controlled circuit and including a condenser so as to insulate the second electrode from the controlled circuit, and means for automatically and quickly discharging electric charges accumulated on the second electrode.

5. An apparatus for amplifying or detecting electrical variations having, in combination, an evacuated vessel, an electrode in the vessel, an ionizing agency in the vessel, a controlled electric circuit connected between the ionizing agency and the electrode, means for impressing an electromotive force on the controlled circuit and acting normally to cause a current flow through the vessel between the ionizing agency and the electrode, means for from time to time temporarily decreasing the apparent conductivity of the space between the ionizing means and the electrode including a second electrode in the vessel and a controlled circuit including a condenser and connected to the second electrode, and means operating upon a decrease of the current in the controlled circuit below a predetermined amount for discharging electric charges accumulated on the second electrode.

6. An apparatus for amplifying or detecting electrical variations having, in combination, an evacuated vessel, an ionizing agency in the vessel, an electrode in the vessel, a controlled electric circuit connected between the ionizing agency and the electrode, means for impressing an electro-motive force on the controlled circuit and acting normally to cause a current flow through the vessel between the ionizing agency and the electrode, means for from time to time temporarily decreasing the apparent conductivity of the space between the ionizing agency and the electrode including a second electrode interposed between the ionizing agency and the first electrode and a controlling circuit connected between the second electrode and the controlled circuit, a condenser in the controlling circuit serving to insulate the second electrode from the controlled circuit, and current-operated means acting upon a decrease of the current in the controlled circuit below a predetermined amount to shunt the condenser.

7. An apparatus for amplifying or detecting electrical variations having, in combination, an evacuated vessel, an electrode in the vessel, an ionizing agency in the vessel, a controlled electric circuit connected between the ionizing agency and the electrode, means for impressing an electro-motive force on the controlled circuit, a second electrode in the vessel, a controlling electric circuit connected with the second electrode and including a condenser, and a relay for preventing the accumulation of too great an electric charge on the second electrode.

8. An apparatus for amplifying or detecting electrical variations having, in combination, means for maintaining a sensitive conducting gaseous space, a plurality of electrodes in the space, a controlled electric circuit connected between two of the electrodes, a controlling electric circuit connected to an electrode other than the controlled circuit electrodes and operating to cause the accumulation of an electrical charge on the controlling circuit electrode, and means external to the gaseous space for preventing the accumulation of too great an electric charge on the controlling circuit electrode.

9. An apparatus for amplifying or detecting electrical variations having, in combination, a high frequency circuit, a rectifying detector connected to said high frequency circuit through a stoppage condenser, a current source connected with the detector, and means operated by currents passed through the detector for discharging charges accumulated on the stoppage condenser.

10. An apparatus for amplifying or detecting electrical variations, having, in combination, a controlling circuit, a rectifying detector connected to said controlling circuit through a stoppage condenser, a current source connected with the detector, and means operated by currents passed through the detector for discharging charges accumulated on the stoppage condenser.

11. An apparatus for amplifying or detecting electrical variations having, in combination, a controlling circuit, a rectifying detector connected to said controlling circuit through a stoppage condenser, and means initiated by the received electrical variations for discharging charges accumulated on the stoppage condenser.

12. An apparatus for amplifying or detecting electrical variations having, in combination, a rectifying detector having a conductor which accumulates a rectified electric charge, and means initiated by the received electrical variations for discharging such accumulated charges.

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1453

H. DE F. ARNOLD.

GASEOUS REPEATER IN CIRCUITS OF LOW IMPEDANCE.

APPLICATION FILED MAY ., 1914.

1,129,942.

Patented Mar. 2, 1915

2 SHEETS—SHEET 1.

Fig. 1.

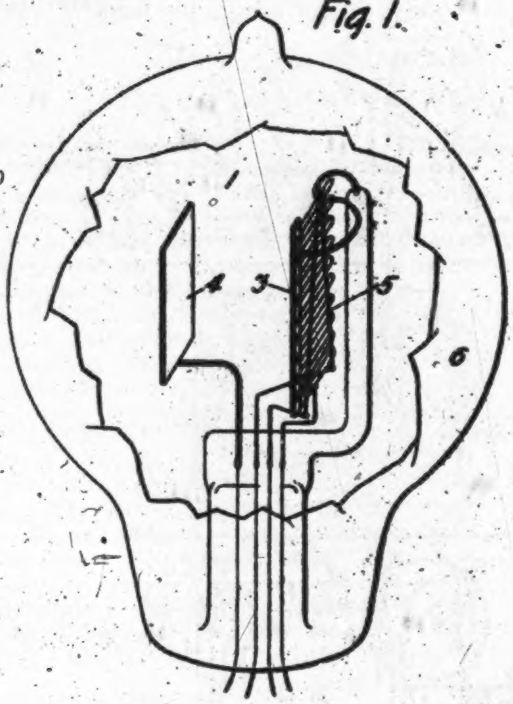
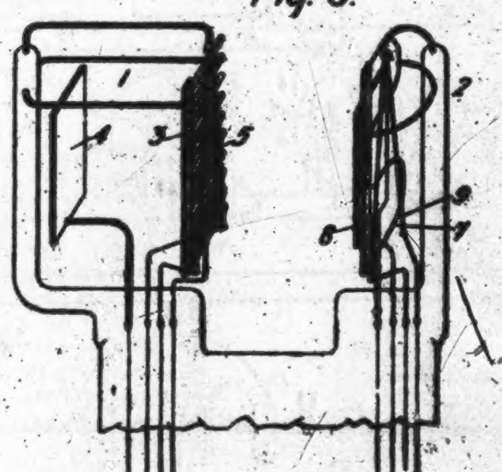


Fig. 2.

Fig. 3.



Witnesses:
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Inventor:
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1454

H. DE F. ARNOLD.

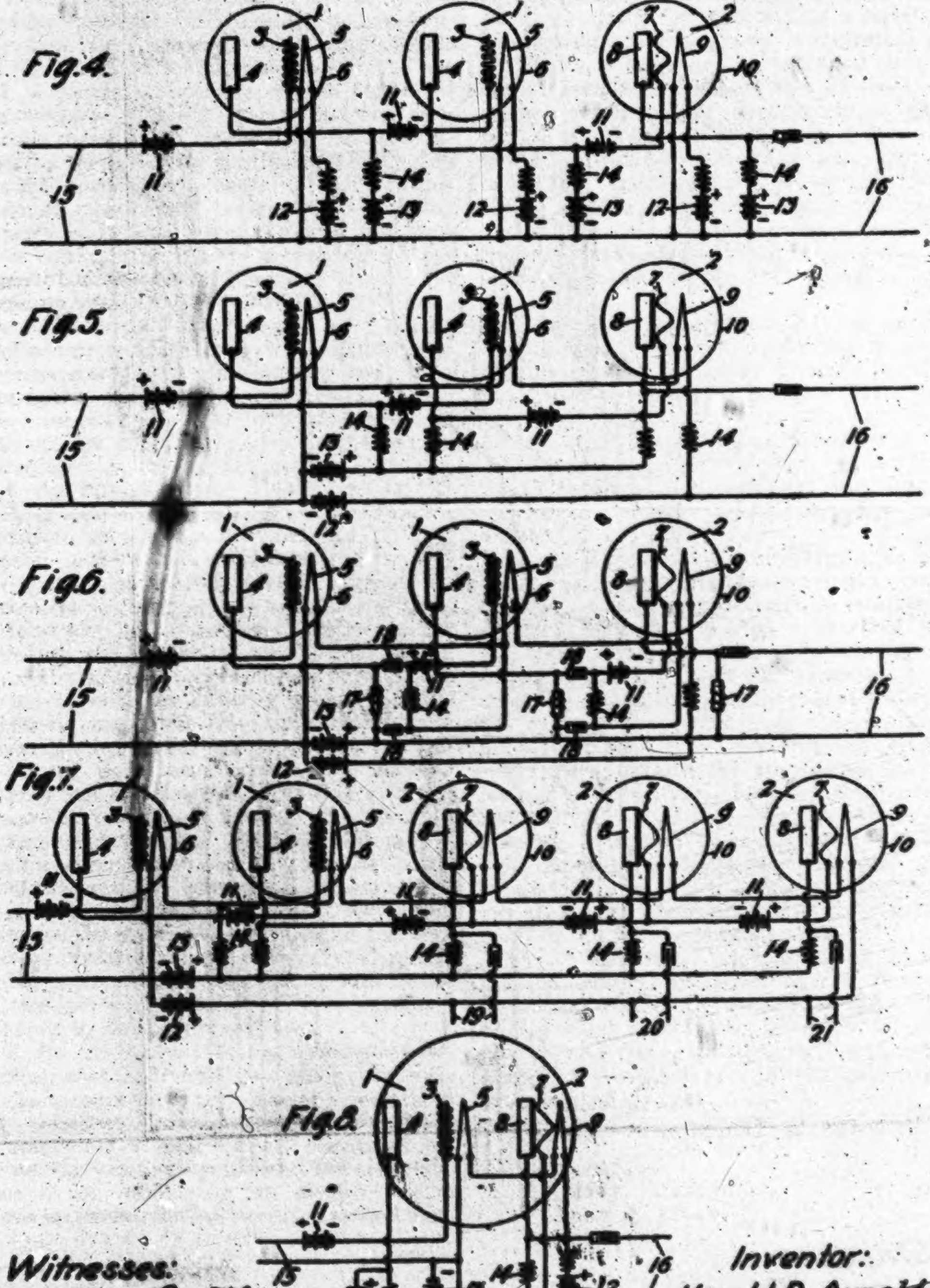
GASEOUS REPEATER IN CIRCUITS OF LOW IMPEDANCE.

APPLICATION FILED MAY 28, 1914.

1,129,942.

Patented Mar. 2, 1915.

2 SHEETS—SHEET 1.



Witnesses:

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1

UNITED STATES PATENT OFFICE.

HAROLD DE FOREST ARNOLD, OF EAST ORANGE, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, OF NEW YORK, N. Y., A CORPORATION OF ILLINOIS.

GASEOUS REPEATER IN CIRCUITS OF LOW IMPEDANCE.

1,129,942. Specification of Letters Patent. Patented Mar. 2, 1915.

Application filed May 28, 1914. Serial No. 841,565.

To all whom it may concern:

Be it known that I, Harold De Forest Arnold, a citizen of the United States, residing at East Orange, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Gaseous Repeaters in Circuits of Low Impedance, of which the following is a full, clear, concise, and exact description.

This invention relates to the use of repeaters generally, and of vacuum discharge repeaters more particularly, as amplifiers without transformers.

Still more particularly, it relates to the use of thermionic repeaters for securing amplification of current in circuits of low impedance. By a thermionic current is meant current discharge from a hot cathode. Examples of thermionic repeaters are the De Forest audion disclosed in Patent No. 879,532, dated February 18, 1914, and others, the Von Leiben & Riesz repeater disclosed in Patent No. 1,038,910, dated September 17, 1912, etc. By vacuum discharge is meant current discharge between electrodes in space from which nearly all atmosphere is exhausted. The expression vacuum discharge repeaters is intended to include repeaters of the thermionic types and also those in which current flows between electrodes in space maintained in a conductive state by the arc or otherwise. The mercury arc repeater of an earlier application of this applicant, Serial No. 709,445, filed July 13, 1912, is an example of the class of vacuum discharge repeaters but it is not of the thermionic type.

In many instances it is necessary or desirable, for securing the best results, to exclude transformers from the circuit. Such is the case, for example in those circuits in which the frequency is so low that efficient transformers are costly and difficult to design, as is the case in telegraph circuits in general and especially in submarine and wireless telegraph circuits. It is particularly desirable to exclude transformers from circuits in which an exact reproduction of wave form is necessary for legibility, as, for example, in submarine cable circuits. It is also desirable to exclude transformers from circuits in which undistorted amplification must be secured over a wide range of frequencies, as, for example, in the reproduction of speech and music.

Heretofore it has been necessary to employ transformers in circuit with the audion in order to secure efficient amplification of current by the audion, and this is especially true where the amplification is desired in circuits of low impedance. This is due to the fact that the impedance of the input circuit of an efficiently operating audion is very high, at least 100,000 ohms and in general as high as 10 megohms. Hence, in a circuit of low impedance, if no transformer is used, the larger part of the possible current amplification by the audion is lost. For example, if the impedance of the input circuit of the audion is only 100,000 ohms and the input circuit of the audion be connected, without the use of transformers, in a line of 1000 ohms impedance, at least 90% of the possible current amplification is lost. Moreover, in the case of audions of the prior art, the impedance in the output circuit of the audion is always so great that a considerable additional loss of possible amplification must occur if the output circuit of the audion is directly connected to a circuit of low impedance.

It has been discovered that audions of the usual type may be so constructed that, without the use of transformers, they will step up the input voltage of either direct current or alternating current of any frequency in one step to as much as 30 times its original value, or in two successive steps to as much as 500 times its original value. The voltage amplification thus secured is entirely free from wave distortion whatever may be the initial frequency and wave form. This type of audion will, for convenience, be hereinafter referred to as the high-voltage output audion.

It has furthermore been discovered that audions may be constructed which will step down the input voltage, for example, to one-

third of its original value. This last mentioned type of audion has a high current and a low voltage output. Because of its low output impedance, such type of audion can be worked efficiently into a line of like impedance. This new type of audion will, for convenience, hereinafter be referred to as the high-current output audion.

The structures which will provide the greatest degree of efficiency in the above mentioned different types of audions form the subject-matter of a copending application in my name, Ser. No. 841,567 filed of even date herewith.

It has been discovered that a combination of one or more of the aforementioned high-voltage output type of audions working into one of the high-current output type, will operate, without transformers, from a line of low impedance, for example, 250 ohms, into a like line with a resultant current much greater, fifty or more times greater, than would flow in the second circuit if it were directly connected to the first circuit. The present invention is directed to such combination of two different types of repeaters, preferably audions. A system designed to secure the same result and employing a large number of the high-voltage output type of audions connected in multiple and working into a common output circuit in lieu of a single audion of the high-current output type, forms the subject-matter of still another application for patent in my name, Ser. No. 841,569 filed of even date herewith.

The present invention may be more readily understood by reference to the accompanying drawings in which—

Figure 1 is a view in perspective of an audion of the high-voltage output type; Fig. 2 is a similar fragmentary view of an audion of the high-current output type; Fig. 3 is a similar fragmentary view of the two different types of audions embodied in a unitary structure; Fig. 4 shows a circuit arrangement embodying this invention in which a plurality of audions of the high-voltage type in tandem work into an audion of the low-voltage type; Fig. 5 shows a simplified circuit arrangement giving the same result as in Fig. 4; Fig. 6 shows a still further modification more particularly applicable to telephone circuits; Fig. 7 shows a plurality of audions of the high-voltage type in tandem working into a plurality of audions of the high-current output type, each of the latter working into a separate output line; and Fig. 8 shows a circuit arrangement embodying the invention in which the two different types of audions are combined in one bulb.

Like reference characters designate like parts throughout the several views.

In the drawings, the audions 1 are of the high-voltage output type and the audions 2 are of the high-current output type. In the former type, the input electrode may be in the form of a grid, preferably made of very fine wire with a fine mesh or the like, and the output anode of plate 4 is placed at a considerable distance from the cathode which is preferably a filament 5, as shown. The filament need not present a large active area. The filament, grid and plate are as usual sealed in an evacuated bulb 6. In order to secure best results in this type of audion, the grid should be near the filament, the plate should be distant from the filament, and the grid should present a finely meshed or discontinuous surface between the filament and the plate.

In the high-current output type of audion, the input electrode or grid 7 may be at any side of the filament and should have a coarse mesh or preferably consist merely of a short length of wire. The output electrode or plate 8 is placed as near to the filament 9 as is conveniently possible. The filament preferably presents a large, active area. The filament, grid and plate are as usual sealed in an evacuated bulb 10. In order to secure the best results in this type of audion, the grid and plate should both be near the filament, the filament area should be large, and the grid should present the least possible obstruction between the filament and plate.

As hereinbefore stated, the high-voltage output type of audion gives an amplification with low current and high voltage in its output circuit; whereas the high-current output type gives amplification with high current and low voltage, and hence low impedance, in its output circuit.

In Fig. 4, two high-voltage output audions 1, 1 connected in tandem are shown working into a high-current output audion 2. The batteries 11 are preferably of such value as to make each of the grids 3, 3 and 7 normally about five volts negative with respect to its adjacent filament. The several filaments are heated by the respective batteries 12. The output circuit of each audion includes its plate, a high resistance 14, a battery 13 and the filament of the audion. The resistance 14 should be, for example, 100,000 ohms or more. The input circuit of the first audion of the group is directly connected to the input line 15. The input voltage on the grid of the first audion 1 causes an increase in the voltage of the current flowing in the output circuit of said audion, thereby producing a voltage change on the grid of the next audion of the series, and so on. As a result of such construction and arrangement of these audions, the voltage in the input circuit of the second of the two

audions in tandem is much greater than that impressed upon the first, although the current in the interconnecting circuit is small. The audion 2 acts as an amplifier in which the current is increased and the voltage lowered in its output circuit. Because of the fact that the impedance in the output circuit of the audion 2 is lowered, it can be worked efficiently into a line 16 of low impedance. It has been found, for example, that the amplifying means shown in Fig. 4 will work from an incoming line of 250 ohms impedance into an outgoing line of like impedance with a resultant current of more than fifty times that which would flow in the outgoing line if the latter were directly connected to the incoming line.

Fig. 5 shows a simplification of the system illustrated in Fig. 4, in that a common battery 12 furnishes current to all the filaments, said filaments being connected in series with the battery, and a common battery 13 serves for all of the plates.

Fig. 6 shows a further simplification of the system illustrated in Fig. 5. An impedance coil 17 is included in bridge of the output circuit of each audion, and in the output circuit of the two audions 1, 1, condensers 18, 18 are inserted in series with the resistances 14. By such arrangement the several batteries 11 may be largely reduced in voltage. This arrangement is particularly applicable to embodiment in a telephone system.

Fig. 7 shows a plurality of the high-voltage output audions in tandem working into a plurality of the high-current output audions, each of the latter working into its own output circuit 19, 20 or 21. Otherwise, the circuit arrangement is substantially that shown in Fig. 5. The arrangement shown in Fig. 7 is particularly applicable to the operation of several loud-speaking receivers from a common talking circuit.

Fig. 8 shows a structure and circuit arrangement in which an audion of the high-voltage output type works into an audion of the high-current output type, the two audions being contained in a single bulb and operating from a common filament having one branch 5 for the audion 1 and another branch 9 for the audion 2. The input electrode 7 of the audion 2 is shown in the form of a short length of wire. The circuit arrangement is substantially that illustrated in Figs. 4 and 5, and further description thereof is deemed unnecessary. This structure and arrangement have been found to operate successfully, without the interposition of transformers, between lines of the impedance of ordinary telephone lines.

As applied to submarine cable work for amplifying the feeble current at the receiving end the invention is of special importance. The large amplification attained makes it possible to operate over such cables at greatly increased speed. Furthermore, less delicate recording devices will suffice as a substitute for the ordinary siphon recorder. Moreover, the high amplification secured renders possible the direct repetition from one section of a cable to another or from submarine to land telegraph lines. The invention is also particularly adapted for use in circuits where especially pure, loud reproduction of speech or music is desired. In general in the art of submarine, land and wireless telegraphy, the invention is of importance with reference to recording, high-speed working and direct repetition from one type of system to another type of system.

What is claimed is:

1. The combination with a source of feeble electric currents, of a thermionic repeater having an input circuit directly connected to said source of current and an output circuit of high voltage, and a second thermionic repeater having an output circuit of low impedance and having an input circuit directly connected to the output circuit of said first mentioned repeater.

2. The combination with a plurality of thermionic repeaters connected in tandem, the first repeater of the series having a high-voltage output and the last repeater of the series having a high-current output.

3. The combination with an incoming and an outgoing line of low impedance, of a plurality of thermionic repeaters in tandem, the first of said repeaters having a high-voltage output and the last of said repeaters having a high-current output, and the first of said repeaters having its input circuit directly connected to said incoming line, and the last of said repeaters having its output circuit directly connected to said outgoing line.

4. The combination with a line of low impedance, of a current amplifying means directly connected therewith, said amplifying means comprising a plurality of thermionic repeaters in tandem, the first of said repeaters having a high-voltage output and the last of said repeaters having a high-current output.

5. The combination with a repeater, of a plurality of vacuum discharge repeaters connected in multiple with the output circuit of said first mentioned repeater, said mentioned repeater having a high-voltage output and said other repeaters each having a high-current output.

6. The combination with a thermionic repeater, of a plurality of thermionic repeaters connected in multiple into which said first mentioned repeater works, said first mentioned repeater having a high-voltage

output and said other repeaters having a high-current output.

7. The combination of two thermionic repeater structures connected in tandem and having a common inclosing bulb, the first of said structures having a high-voltage output and the other a high-current output.

In witness whereof, I hereunto subscribe my name this 25 day of May, A. D. 1914.

HAROLD DE FOREST ARNOLD.

Witnesses:
E. EDLER,
K. L. STAHL.

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1459

H. DE F. ARNOLD.
GASEOUS REPEATER IN CIRCUITS OF LOW IMPEDANCE.
APPLICATION FILED MAY 23, 1914.

1,129,943.

Patented Mar. 2, 1915.

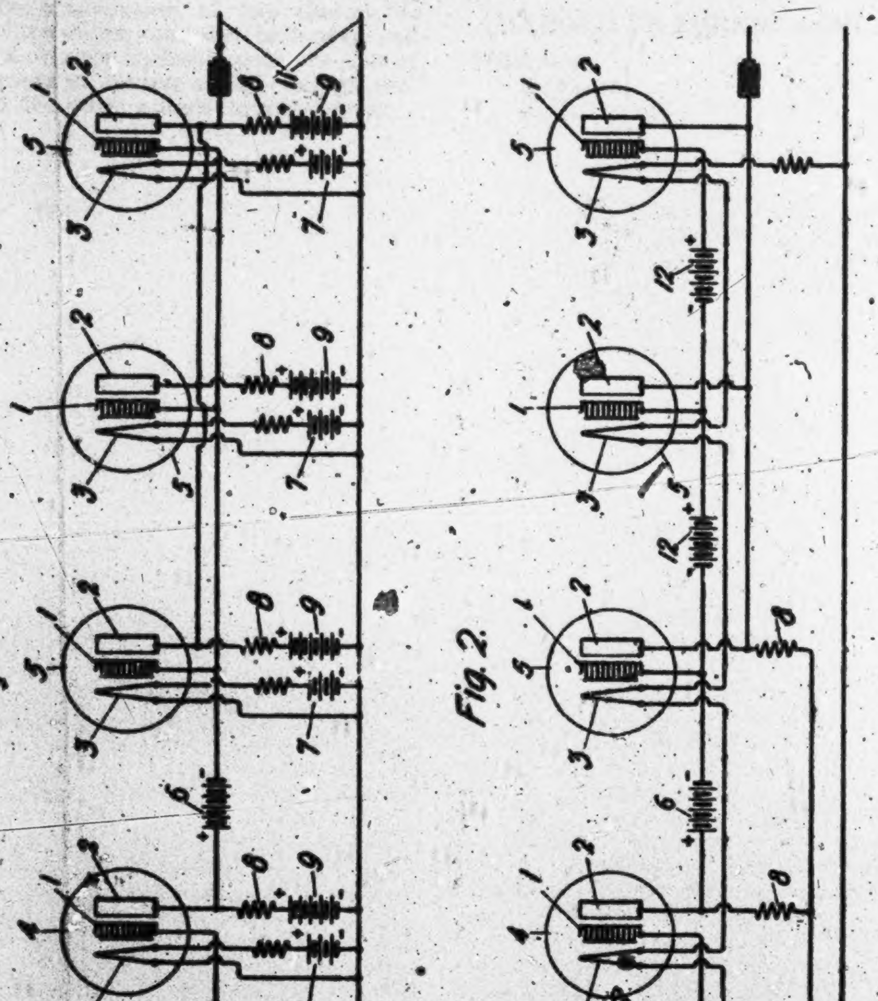

Fig. 1.

Fig. 2.

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Inventor:
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by A. C. Stearns
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UNITED STATES PATENT OFFICE.

HAROLD DE FOREST ARNOLD, OF EAST ORANGE, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, OF NEW YORK, N. Y., A CORPORATION OF ILLINOIS.

GASEOUS REPEATER IN CIRCUITS OF LOW IMPEDANCE.

1,129,943. Specification of Letters Patent. Patented Mar. 2, 1915.

Application filed May 28, 1914. Serial No. 841,569.

To all whom it may concern:

Be it known that I, HAROLD DE FOREST ARNOLD, a citizen of the United States, residing at East Orange, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Gaseous Repeaters in Circuits of Low Impedance, of which the following is a full, clear, concise, and exact description.

This invention relates to the use of thermionic repeaters, such as the audion, as amplifiers without transformers, and more particularly to the use of thermionic repeaters for securing amplification of current in circuits of low impedance.

In many instances it is necessary or desirable, for securing the best results, to exclude transformers from the circuit. Such is the case, for example, in those circuits in which the frequency is so low that efficient transformers are costly and difficult to design, as is the case in telegraph circuits in general and especially in submarine and wireless telegraph circuits. It is particularly desirable to exclude transformers from circuits in which an exact reproduction of wave form is necessary for legibility, as, for example, in submarine cable circuits. It is also desirable to exclude transformers from circuits in which undistorted amplification must be secured over a wide range of frequencies, as, for example, in the reproduction of speech and music.

Heretofore it has been necessary to employ transformers in circuit with the audion in order to secure efficient amplification of current by the audion, and this is especially true where the amplification is desired in circuits of low impedance. This is due to the fact that the impedance of the input circuit of an efficiently operating audion of the usual type is very high, at least 100,000 ohms and in general as high as 10 megohms. Hence, in a circuit of low impedance if no transformer is used, the larger part of the possible current amplification by the audion is lost. For example, if the impedance of the input circuit of the audion is only 100,000 ohms and the input circuit of the audion is connected, without the use of transformers, in a line of 1000 ohms impedance, at least 99% of the possible current amplification is lost. Moreover, in the case of audions of the prior art, the impedance in the output circuit of the audion is always so great that a considerable additional loss of possible amplification must occur if the output circuit of the audion is connected without the use of a transformer in a circuit of low impedance.

It has been discovered that audions may be so constructed that without the use of transformers they will step up the input voltage of either direct current or alternating current of any frequency in one step to as much as thirty times its original value, and in two successive steps to as much as 500 times its original value. The voltage amplification thus secured is entirely free from wave distortion whatever may be the initial frequency and wave form. It has been discovered that the output voltage of one of such audions or of a plurality thereof in tandem may be stepped down and the resultant current greatly amplified by having such audion or plurality of audions work into a plurality of similar audions in multiple, with the output of each going to a common circuit. This common output will be an amplified current of relatively low voltage. It has been discovered that a combination of one or more of such audions working into a sufficiently large number, for example from fifty to one hundred, of similar audions in multiple, with a common output, will operate, without transformers, from a line of low impedance, for example 250 ohms, into a like line with a resultant current much greater, fifty or more times as great, than would flow in the second circuit if it were directly connected to the first circuit. The present invention is directed to such combination of audions. A system designed to secure the same result and employing a single audion of a special type, in lieu of such audions in multiple, forms the subject-matter of another application for patent in my name, Ser. No. 841,568 filed of even date herewith.

The present invention may be more readily understood by reference to the accompanying drawings in which—

Figure 1 shows a circuit arrangement embodying this invention in which a plu-

rality of audions in tandem work into a plurality of similar audions in multiple, the output going to a common circuit; and Fig. 2 shows a simplified circuit arrangement giving the same result as in Fig. 1.

Like reference characters refer to like parts in both of said figures of the drawings.

The several audions may be of the usual construction, but to secure most efficient results the input electrode may be in the form of a grid 1, preferably made of very fine wire with a fine mesh or the like, and the output electrode or plate 2 is placed at a considerable distance from the filament 3. The filament, grid and plate are as usual sealed in an evacuated bulb. In order to secure best results, the grid should be near the filament, the plate should be distant from the filament, and the grid should present a finely meshed or discontinuous surface between the filament and the plate. This type of audion is adapted to give an amplification with low current and high voltage in its output circuit.

In Fig. 1, two audions 4, 4 in tandem are shown working into three audions 5, 5, 5 in parallel. The number of audions 4 in tandem employed will depend upon the amount of amplification desired. In case more than one audion 4 is used, they are, as shown, connected in tandem. Likewise the number of audions 5 in parallel will depend upon the characteristics required in their common output circuit, an increasing number of such multipled audions 5 giving a decreasing voltage and increasing current. The batteries 6 are preferably of such value as to make each of the input electrodes or grids 1 normally about five volts negative with respect to its adjacent filament 3. The several filaments are heated by the respective batteries 7. The output circuit of each audion includes its output electrode or plate 2, a high resistance 8, a battery 9 and the filament of the audion. The resistance 8 should be, for example, 100,000 ohms or more. The input circuit of the first audion of the group is directly connected to the input line 10. The input voltage on the grid of the first audion 4 causes an increase in the voltage of the current flowing in the output circuit of said audion, thereby developing a voltage change on the grid of the next audion 4 in series. As a result of such construction and arrangement of these audions, the voltage in the input circuit of the second of the two audions in tandem is much greater than that impressed upon the first, although the current in the interconnecting circuit is small. The audions 5 work into a common output line 11 and being connected in parallel act to step down the voltage and correspondingly increase the current. This presents to the common output line 11 an impedance inversely proportional to the number of the multipled audions. Hence for the most successful operation into a line of low impedance, for example, [illegible]0 ohms, a large number of audions in parallel would be required to provide in their common output line 11 an impedance approximately equal to the impedance of the line to which direct connection is to be made. By combining two or more audions in tandem working into a number of audions in multiple, for example, from ten to one hundred, the combined system will operate, without the use of transformers, from an incoming line of low impedance into an outgoing line of like impedance with a resultant current of more than fifty times that which would flow in the outgoing line if the latter were directly connected to the incoming line.

Fig. 2 shows a simplification of the system illustrated in Fig. 1, in that a common battery 7 furnishes current to all the filaments, said filaments being connected in series with the battery. The batteries 12, 12 are introduced to compensate for the voltage drop through the filaments. A common battery 9 serves for all of the output electrodes 2.

As applied to submarine cable work for amplifying the feeble current at the receiving end, the invention is of special importance. The large amplification attained makes it possible to operate over such cables at greatly increased speed. Furthermore, less delicate recording devices will suffice as a substitute for the ordinary siphon recorder. Moreover, the high amplification secured renders possible the direct repetition from one section of a cable to another or from submarine to land telegraph lines. The invention is also particularly adapted for use in circuits where especially pure or loud reproduction of speech or music is desired. In general in the art of submarine, land and wireless telegraphy, the invention is of importance with reference to recording, high-speed working and direct repetition from one type of system to another type of system.

What is claimed is:

1. The combination of a plurality of thermionic repeaters in multiple having a common output line, and a thermionic repeater working into said multipled repeaters.

2. The combination of a set of thermionic repeaters in multiple having a common output line, and a set of thermionic repeaters in tandem working into said first mentioned set of repeaters.

3. The combination with a line of low impedance, of an audion having its input circuit directly connected to said line, and a plurality of audions in multiple into which said first mentioned audion works, said multipled audions having a common output line.

4. The combination with an incoming and an outgoing line of low impedance, of a set of audions in tandem directly connected to said incoming line, and a set of audions in multiple into which said first mentioned set works, said last mentioned set being directly connected to said output line.

In witness whereof, I hereunto subscribe my name this 25 day of May A. D., 1914.

HAROLD DE FOREST ARNOLD.

Witnesses:

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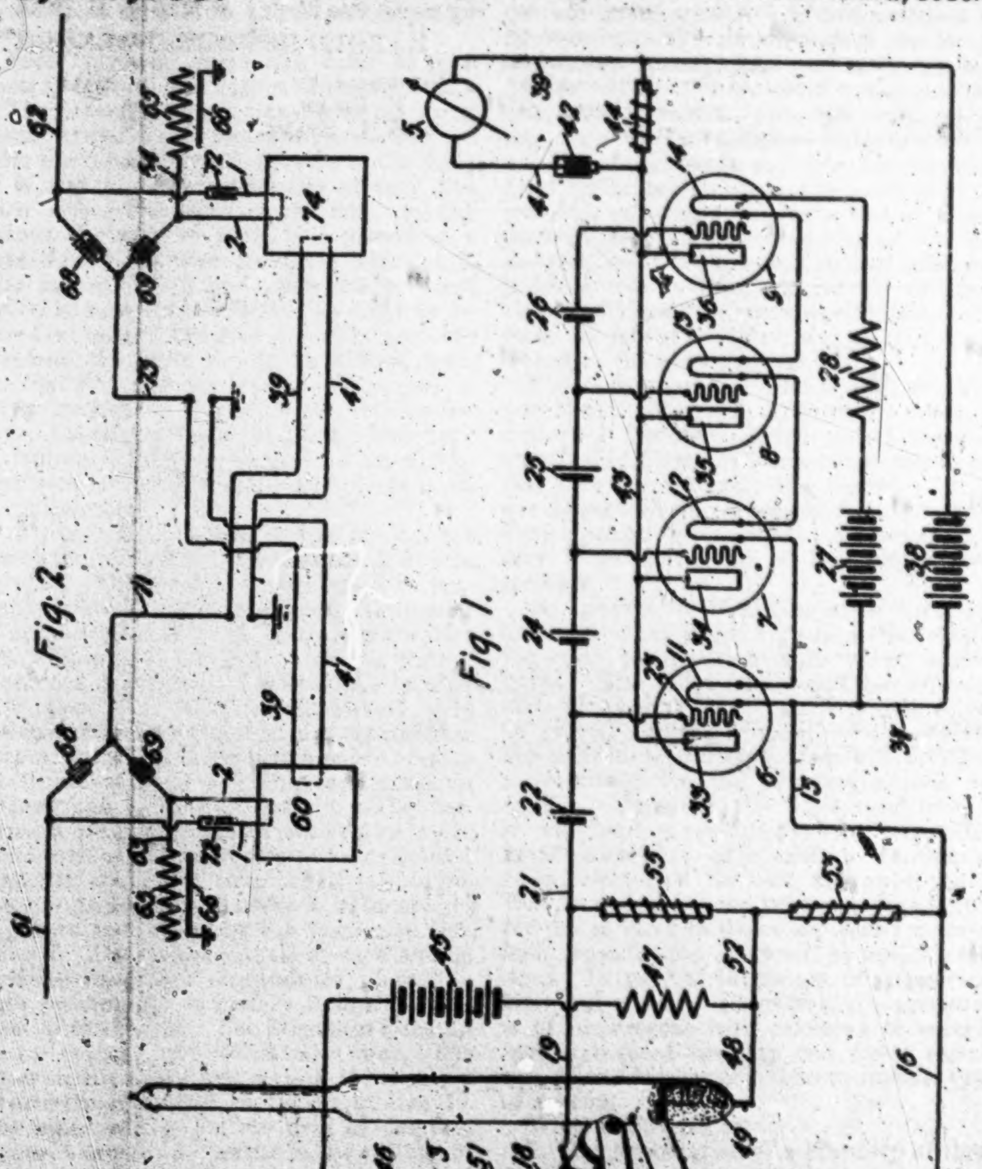
K. L. STAHL.

1463

E. H. COLPITTS.
SYSTEM FOR AMPLIFYING ELECTRIC WAVES.
APPLICATION FILED APR. 6, 1914.

1,129,959. Patented Mar. 2, 1915.



Witnesses:
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Inventor:
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By John G. Roberts
Atty.

UNITED STATES PATENT OFFICE.

EDWIN H. COLPITTS, OF EAST ORANGE, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, OF NEW YORK, N. Y., A CORPORATION OF ILLINOIS.

SYSTEM FOR AMPLIFYING ELECTRIC WAVES.

1,129,959. Specification of Letters Patent. Patented Mar. 2, 1915.

Application filed April 8, 1914. Serial No. [illegible].

To all whom it may concern:

Be it known that I, EDWIN H. COLPITTS, a subject of the King of Great Britain, residing at East Orange, in the county of Essex and State of New Jersey, have invented a certain new and useful Improvement in Systems for Amplifying Electric Waves, of which the following is a full, clear, concise, and exact description.

This invention relates to electric signaling, and particularly to signaling over ocean cables.

One of its objects is to amplify efficiently very feeble low frequency electric waves.

A special object is to provide an efficient amplifying system adapted without transformers for use at the receiving end of a signaling circuit.

A well known law of electric circuits requires that the impedance of the external path in the circuit should be equal to the impedance of the internal path or source, whenever the maximum of available energy is desired. In ocean cable telegraphy it is usual to connect a siphon recorder directly to the land terminals of the cable circuit. In order, therefore, to utilize in the recorder the maximum energy obtainable, the receiving magnet of the recorder should be wound to offer an impedance of the same order of magnitude as that of the cable circuit measured at its incoming terminals. For example, if the impedance of the cable circuit measured at its incoming terminals to currents at telegraphic frequency is say, 2000 ohms, the best impedance for the recorder magnet would in this case also be 2000 ohms. When such an equalization of impedances is secured, the circuit may be said to be balanced. But, if the impedances of the source and of the receiving device are greatly out of proportion, there is an unbalanced condition and a loss of available energy.

Of the various types of known amplifying devices, those in the general class of vacuum discharge repeaters such as the ionized gas type and the type known as thermionic exemplified by the "audion" have advantages with respect to amplifying very low frequency currents, since the output currents in such devices are not subject to severe distortion due to external or internal disturbances, but are substantially determined as to their form by the form of the input current. Furthermore, ionized gas repeaters of the species which make use of electromagnets for receiving incoming currents, may readily have their magnets wound to approximately the impedance of cable circuits so that they may be operated efficiently, when directly connected to the incoming terminals of such circuits. Also as to audions, it is noted that the impedance of their output circuits, although considerably higher than that of the ordinary siphon recorder used in ocean cable telegraphy is not usually so high as that of their input circuits and may, by suitable arrangements, be rendered still lower, thereby adapting the audions for direct connection to recorders. One way of lowering the output impedance is to employ a plurality of audions having their output circuits connected in parallel. In this way the impedance may be reduced sufficiently to form fairly well balanced connections with recorders. The ionized gas repeater, however, has an output circuit of the order of several hundred thousand ohms impedance, while the audion has an input circuit of similar high impedance. Such impedances are so out of proportion to that of a cable circuit or that of any practical winding for a siphon recorder, that a direct connection between the output terminals of the gaseous repeater and a siphon recorder, or one between the input terminals of an audion or even a bank of audions in multiple and a cable circuit would result in inefficient operation. Furthermore, on account of the very low frequency of the minute electric waves in cable telegraphy, these waves in certain cases as in ocean telegraphy being as low as two periods per second, it is extremely desirable to avoid the use of a transformer, the design of which for use in conjunction with vacuum discharge repeaters, such as ionized gas or thermionic repeaters or the like, between the cable and the recorder would be a very difficult matter.

The unbalanced condition and inefficient operation which would be met in the use without a transformer of any known type of vacuum discharge repeater and the necessity of using the undesirable transformer to balance impedances are at once avoided in accordance with this invention by the use of two or more vacuum discharge repeaters having different impedance characteristics and working one into the other by direct

connection. Two such vacuum discharge repeaters may be placed in *seriation* between the cable and receiver, the one connected with the cable having high output impedance and preferably also a comparatively low input impedance such as the ionized gas repeater, and the one or more connected with the receiver having high input impedance such as the audion, and preferably arranged to offer a comparatively low output impedance. The output-input circuit between two such amplifying repeaters placed in this relation including as it does high impedance paths in both, is electrically balanced and the system as a whole is well adapted for efficient amplification. Naturally the voltage and current characteristics of this high impedance output-input circuit are such that the voltage changes are high and the current changes low, in comparison with the voltage and current changes in the input circuit of the first repeater.

A system embodying the invention will be described more in detail in the following specification together with the accompanying drawings in which—

Figure 1 is a diagram of circuits as applied to an ocean cable and a recorder; and Fig. 2 is a diagram showing the application of the invention to the juncture of two cable sections where the currents received from one section are repeated in the other.

Referring to Fig. 1, the circuit of an ocean cable is represented by conductors 1 and 2 leading to an ionized gas repeater 3 and connected directly in circuit with an electro-magnet 4 thereof. A receiving device 5, which may be a siphon recorder, is provided for reproducing or recording the electric waves received through the cable. Between the repeater 3 and recorder 5 are connected a plurality of repeaters of the audion type 6, 7, 8 and 9. The output circuit of the gaseous repeater 3 is connected with the input circuit of each of the audions 6 to 9, the complete circuit being as follows: from the filaments 11, 12, 13 and 14 of the audions, through conductors 15 and 16 to an electrode 17; thence through the ionized gas in the repeater to another electrode 18, and through conductors 19 and 21, battery 22, grid 23 of audion 6, and the space between the grid and filament. Parallel paths lead through the grids and spaces in each of the audions. Batteries 24, 25 and 26 are included in extensions of the conductor 21 in order to equalize approximately the normal potential differences between the grids and filaments in the several audions, it being noted that the filaments are connected in series and fed by a battery 27, the circuit of which includes a resistance 28 to regulate the flow of current. The several plates 33, 34, 35 and 36 of the audions are connected in multiple circuit with the receiving device 5, the circuit being traced as follows: from the filaments 11, 12, 13 and 14, through conductor 37, battery 38, conductor 39, receiver 5, conductor 41, condenser 42 and conductor 43 to the several plates 33 to 36; thence in parallel through the spaces between the plates and filaments in each audion. Connected across this circuit is an impedance device 44, the coil of which serves as the path for a normal flow of direct current from the battery 38 to the several audions. This device is of high impedance so as to avoid shunting the varying currents generated in the output circuit of the audions.

A normal flow of current to the gaseous repeater 3 is supplied by battery 45, one pole of which is connected to an anode 46 and the other of which is connected through a regulating resistance 47 and conductor 48 to a cathode 49. This cathode 49, in the preferred form of the device, is of mercury and an arc is formed between the cathode 49 and the anode 46 which completes the circuit of battery 45 and causes the formation of an ionized gas (mercury) in the vessel 51. This gas renders the space conductive between the electrodes 17 and 18 and the anode 46. A normal flow of current is provided in the output circuit of the repeater 3 also from the same battery 45, the circuit extending from the negative pole of the battery 45, through the resistance 47 to conductor 52, where the circuit divides, one branch leading through impedance coil 53, conductor 16, the electrode 17, and that part of the ionized gas which lies between this electrode and the anode 46, to the positive pole of battery 45. The other branch may be traced similarly through the impedance coil 55, conductor 19, the electrode 18, and that part of the ionized gas which lies between the electrode 18 and the anode 46.

The operation is as follows: The feeble currents of low frequency received in the input circuit from the cable circuit conductors 1, 2 produce, by means of the electromagnet 4, a fluctuating magnetic field and a corresponding varying deflection of the gaseous ions to the right and left in the region of the electrodes 17, 18. This causes a corresponding varying flow of current of amplified energy in the conductors 16 and 19 and therefore in the output-input circuit between the gaseous repeater 3 and the audions 6 to 9. These audions, each of which receives a part of the energy of this current, reproduce the waves of current with amplified energy in the output circuit leading to the receiver 5. The different parts of these circuits are or may be balanced electrically in the following manner: The electromagnet 4 of the gaseous repeater 3 may be wound to any impedance desired, thus making it of an impedance of the same order of magnitude as the cable from which it

receives energy. By using a number of audions in the way shown in Fig. 1, the combined impedance of the output circuit may be made of the same order of magnitude as the receiver or siphon recorder. The output-input circuit between the gaseous repeater 3 and the audions is naturally well balanced, inasmuch as the output circuit of the gaseous repeater and the input circuit of the audions are both of high impedance and approximately of the same order of magnitude.

In Fig. 2, 61 and 62 are conductors of different cables which may terminate at the same landing point and form sections of a common circuit. Where two-way transmission or duplex operation is desired in such a circuit, an artificial line, such as the lines 63 and 64, are provided for each conductor. Each such artificial line may comprise a resistance 65, and distributed capacity between this resistance and a ground plate 66. The cable conductor and its artificial line are joined by two condensers of large capacity 68 and 69, and at the junction point between these condensers a conductor 71 leads through suitable apparatus to ground. In applying this invention to the repeating of currents from one such cable conductor to the other, the input circuit (conductors 1 and 2) of a repeater set 60, like that of Fig. 1, may be connected in bridge between the cable conductor 61 and its artificial line 63, and a condenser 72 may be inserted in this bridge, while the output circuit (conductors 39 and 41) of the set may be connected in the ground conductor 73 of the other cable conductor 62. This provides for signaling from conductor 61 to conductor 62. For signaling in the opposite direction the arrangement is exactly similar. As shown, the input circuit (conductors 1 and 2) of a second repeater set 74, also like that of Fig. 1, is connected in bridge of the cable conductor 62 and its artificial line 64, while the output circuit (conductors 39, 41) of the set is connected in the ground conductor 71. By this arrangement messages may be transmitted in both directions simultaneously in the through circuit of the cable conductors 61 and 62, and the currents amplified at the point where the sections are united.

What is claimed is:

1. The combination with a low impedance source of varying currents and a receiver adapted to respond to such currents, of an amplifying repeater connected with said source and having an output circuit of high impedance compared to said source, and a second amplifying repeater connected between said first repeater and said receiver and having an input circuit also of high impedance compared to said source.

2. The combination with a source of varying currents and a receiver adapted to respond to such currents of an ionized gas repeater having an input electromagnet connected to said source and an output circuit including a path through the gas of said repeater, and an audion repeater connected with its input circuit in series with the output circuit of said gas repeater and its output circuit connected to said receiver.

3. The combination with a cable circuit and a receiver adapted to respond to electric waves in said circuit, of two amplifying repeaters connected in *seriatim* between said cable and said receiver, the output-input circuit between said repeaters being of high impedance compared to said cable and to said receiver.

4. The combination with a source of feeble electric waves of low frequency, and a receiver adapted to respond to said waves, of two amplifying repeaters connected in *seriatim* between said source and said receiver, one of said repeaters having an input circuit directly connected with and of impedance of the same order of magnitude as said source, the other of said repeaters having an output circuit connected with said receiver, and a circuit joining said repeaters having paths in each of high impedance compared to said source.

5. The combination with a cable circuit and a receiver adapted to respond to electric waves in said circuit, of an ionized gas repeater having an input electromagnet connected to said cable, a plurality of audion repeaters, the output circuits of which are connected in parallel with each other and in circuit with said receiver, and an output-input circuit including paths through the gas in said first-mentioned repeater and through said audion repeaters.

6. In an amplifying system, the combination of two vacuum discharge repeaters having different impedance characteristics and a connection between them whereby one works directly into the other.

7. In an amplifying system, the combination with an ionized gas repeater and a thermionic repeater, of a connection between them whereby said ionized gas repeater works directly into said thermionic repeater.

8. The combination of a thermionic repeater and a vacuum discharge repeater working directly into said thermionic repeater, the said repeaters having different impedance characteristics.

9. The combination of a plurality of thermionic repeaters in multiple having a common output line and a vacuum discharge repeater working into said thermionic repeaters.

10. The combination of a line of low impedance, of a vacuum discharge repeater having a high output impedance, and a second vacuum discharge repeater into which

said first mentioned repeater works, said second repeater having an input impedance of the same order of magnitude as the output impedance of the first mentioned repeater.

11. The combination of a plurality of thermionic repeaters in multiple having a common output line, and an ionized gas repeater working into said thermionic repeaters.

12. The combination of a line of low impedance, of an amplifying repeater having its input circuit directly connected to said line, and a second amplifying repeater into which said first mentioned repeater works the output-input circuit between said repeaters including high impedance paths in each repeater.

13. The combination with an incoming and an outgoing line of low impedance, of a set of repeaters directly connected in *seriatim* between said lines, the output-input circuit between said repeaters being of high impedance with respect to said lines.

In witness whereof, I hereunto subscribe my name this 3rd day of April A. D., 1914.

EDWIN H. COLPITTS.

Witnesses:
KATHERINE L. STAHL,
NORAH E. TUTHILL.

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PAGE

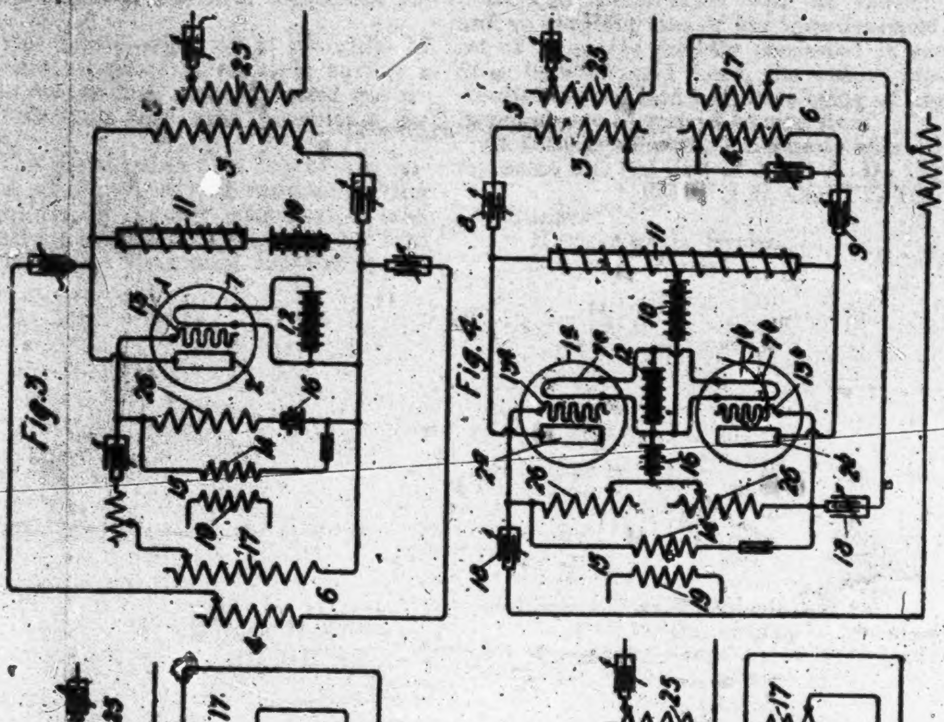
1468

E. H. COLPITTS.

SYSTEM FOR THE TRANSMISSION OF INTELLIGENCE.

APPLICATION FILED MAY 18, 1914.

1,137,384. Patented Apr. 27, 1915.



Witnesses:

O. M. Lukke

John Waldheim

Inventor:

Edwin H. Colpitts.

by A. C. Tanner, Att'y.

UNITED STATES PATENT OFFICE.

EDWIN H. COLPITTS, OF EAST ORANGE, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, OF NEW YORK, N. Y., A CORPORATION OF ILLINOIS.

SYSTEM FOR THE TRANSMISSION OF INTELLIGENCE.

REISSUED

1,137,384. Specification of Letters Patent. Patented Apr. 27, 1915.

Application filed May 18, 1914. Serial No. 838,318.

To all whom it may concern:

Be it known that I, Edwin H. Colpitts, a subject of the King of Great Britain, residing at East Orange, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Systems for the Transmission of Intelligence.

This invention relates to systems for the transmission of intelligence, in which the amplitudes of successive electrical oscillations of high frequency are varied in accordance with the lower frequency forms of the messages delivered.

Its object is to simplify the mechanism and to strengthen the effectiveness of the apparatus required for the production of the modulated oscillations.

To these ends the invention embodies a repeater which serves not only as a generator of high frequency oscillations, but also as a means for modulating the oscillations in accordance with the low frequency signaling impulses to be transmitted.

The invention is adapted for embodiment in systems of wireless telegraphy and telephony in so-called high frequency wired systems, and in general wherever a receiving device is rendered sensitive to signaling impulses or waves of low frequencies by means of sustained electric or electromagnetic waves of high frequency transmitted from the sending station.

The single device used to perform the two functions referred to may be a repeater, preferably a repeater of the audion type, wherein the output circuit is connected with the input circuit, this arrangement, with proper adjustment of devices in the circuit, resulting in the production of sustained high frequency oscillations. By varying the potential in the input circuit, as for example by connecting a transmitter or other device for sending a message in circuit with one of the electrodes, say the grid, of the audion, the sustained oscillations, it has been found, are then modulated in accordance with the message to be sent. The message may be received or recorded in any desired manner at the distant station.

Several embodiments of the invention will be set forth in the following detail description taken in connection with the accompanying drawings, wherein—

Figure 1 illustrates a system of circuits embodying the invention; and Figs. 2, 3 and 4 are modified circuits therefor.

Like parts are designated alike in the several figures.

Referring first to Fig. 1, an audion 1, the elements of which are inclosed in an evacuated vessel, as usual, is arranged with its output anode or plate 2 connected through the primary windings 3 and 4 of repeating coils 5 and 6 to the negative terminal of the heated filament or cathode 7 of the audion. Included in this output circuit may be located a battery 10 and, as required, adjustable devices, such as the condensers 8 and 9. Bridged across the circuit, to feed battery current to the plate 2, is a coil of high impedance 11. The filament 7 is heated by current from the battery 12. The input electrode or grid 13 of the audion is connected through the secondary winding 14 of a repeating coil 15 to the negative terminal of the filament 7, and included in this, the input circuit, there may be located a battery 16. The secondary winding 17 of the repeating coil 6 is connected through an adjustable condenser 18 with the input circuit, one wire leading to the grid 13 and the other wire to the negative terminal of the filament 7.

The primary winding 19 of the repeating coil 15 may be connected in circuit with the secondary winding 20 of another repeating coil 21, the primary winding 22 of which is connected in circuit with a battery 23 and a sending device, which, as shown, may be a telephone transmitter 24. The repeating coil 5 has a secondary winding 25, the terminals of which lead to the antenna of a wireless system or to the line of a wire circuit, according to the particular use to which the apparatus is put.

The operation of the system illustrated in Fig. 1 is as follows: The audion 1 is rendered active by the heated filament 7, which emits a stream of negative ions across the space intervening between it and the positively charged plate 2. This stream passes through the interspaces of the grid. The battery 10, acting through the resistance of the coil 11, tends to maintain a steady flow of current in the output circuit, including the ionized space between the plate 2 and the filament 7. The flow of current across the ionized space, however, is not steady but is caused to

fluctuate at a very high frequency, by reason of the interaction between the input and output circuits through the repeating coil 6. The frequency of the sustained oscillations produced by this arrangement may be varied by adjusting the capacities of the various condensers in the circuit. The high frequency currents in the output circuit are transmitted by the repeating coil 5 into the line or antenna to which the secondary winding 23 may be connected.

By means of the telephone transmitter 24, the amplitude of the sustained oscillations is modified or modulated in accordance with sound waves which are of a lower order of frequency. This may be explained as follows: At the normal potential of the battery 16 impressed on the grid 13, the sustained oscillations are produced at a constant amplitude. At a higher potential, due to a positive impulse from the winding 14, the current in the output circuit is increased, and the amplitude of the high frequency oscillations is greater. Conversely, at a lower potential, due to a negative impulse, the oscillations become lesser in amplitude than normal. Thus each pulsation of potential, caused by speaking into the transmitter 24, is effective in producing a corresponding variation in the amplitude of oscillations of current, and therefore of energy in the output circuit and likewise in the line or antenna.

In Fig. 2 is shown an arrangement differing from that of Fig. 1 in that the battery 10 thereof, corresponding to the like numbered battery in Fig. 1, is connected in series with the high impedance coil 11 in bridge of the output circuit. The arrangement is also different in that the battery 16 is included in a bridge of the input circuit in series with an adjustable resistance 26.

In Fig. 3 is illustrated a modified circuit in which the battery 10 is included in series with the high impedance coil 11 as it is in Fig. 2, but primary windings 3 and 4 of the repeating coils 5 and 6 are connected in parallel with relation to each other instead of in series as in Figs. 1 and 2.

In Fig. 4 an arrangement is shown in which two audions 1^a and 1^b are used. Here the battery 10 is connected to a central point in the winding of the high impedance coil 11, the outer terminals of which are connected to the two plates 2^a and 2^b, respectively, of the two audions. Battery 16 is likewise connected to a midpoint of an adjustable resistance 26, the outer terminals of which are connected to the two grids 13^a and 13^b. In the system of Fig. 4, therefore, the battery 10 tends to supply a steady flow of current through both audions from the plates 2^a and 2^b to the two filaments 7^a and 7^b, respectively. The battery 12 supplies current to both of the filaments 7^a and 7^b. The operation is such that the impulses from the repeating coils 6 and 15 produce at any instant of time opposite potential variations on the grids 13^a and 13^b, and these opposite potential variations produce an effect which is cumulative in the output circuit to which the plates 2^a and 2^b are connected.

What is claimed is:

1. The combination with a generator of high frequency current, comprising a repeater and an input and an output circuit therefor united with each other, said repeater having an electrode located in said input circuit; of a transmission line united with said output circuit, and a source of low frequency potential variations connected to said electrode.

2. The combination with an audion having a filament, a plate and a grid, an input circuit connected with the grid and an output circuit connected with the plate; of an inductive connection between said output and said input circuits adapted to the production by said audion of sustained high frequency oscillations, and a sending device, adapted for producing signaling impulses of low frequencies, connected with said input circuit.

3. The combination with a generator of high frequency current, comprising a repeater, an input and an output circuit therefor and a connection between said circuits; of a transmission line united with said output circuit, and a sending device, adapted for producing signaling impulses of low frequencies, connected with said input circuit.

4. The combination with a generator of high frequency current, comprising an evacuated vessel, means for producing a state of ionization in said vessel, and an input and an output circuit interconnected to react upon each other; of means connected with said input circuit for producing low frequency potential variations in said input circuit.

5. The combination with a generator of high frequency current, comprising an evacuated vessel, means for producing a state of ionization in said vessel, and an input and an output circuit inductively connected with each other; of a source of low frequency potential variations connected with said input circuit for controlling the amplitude of the high frequency currents developed by said generator.

6. The combination with a generator of high frequency current, comprising an evacuated vessel, means for producing a state of ionization in said vessel, and an input and an output circuit connected with each other; of means included in said circuits for adjusting the frequency of said current; and a source of low frequency potential variations connected with said input

circuit for controlling the amplitude of the high frequency currents developed by said generator.

7. In apparatus of the kind described, the combination of an evacuated vessel and means, including a cathode, for producing a state of ionization in said vessel; of an input anode and an output anode in said vessel; an output circuit connected to said output anode and including an adjustable condenser and a source of continuous current, an input circuit connected to said input anode and inductively connected to said output circuit, and means connected with said input circuit for producing low frequency potential variations in said input circuit.

8. The combination with an audion having an input circuit and an output circuit inductively connected with each other; of means connected with said input circuit for producing low frequency potential variations in said input circuit.

In witness whereof, I hereunto subscribe my name this 15 day of May A. D., 1914.

EDWIN H. COLPITTS.

Witnesses:

E. EDLER,

KATHERINE L. STAHL.

1472

G. A. CAMPBELL.
ELECTRIC WAVE FILTER.
APPLICATION FILED JULY 15, 1915.

1,227,113. Patented May 22, 1917.

3 SHEETS—SHEET 1.

Fig. 1

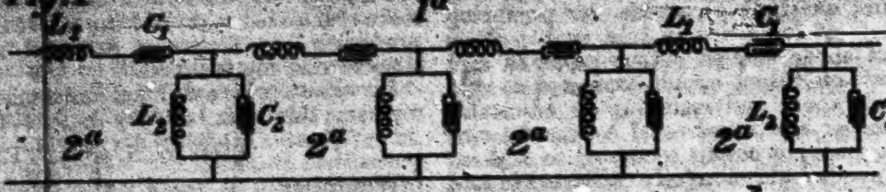


Fig. 2

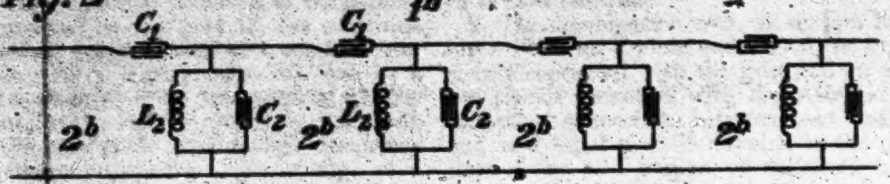


Fig. 3

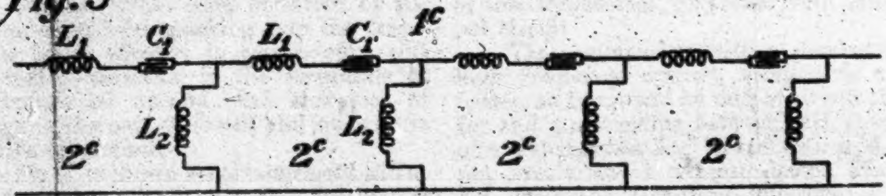


Fig. 4

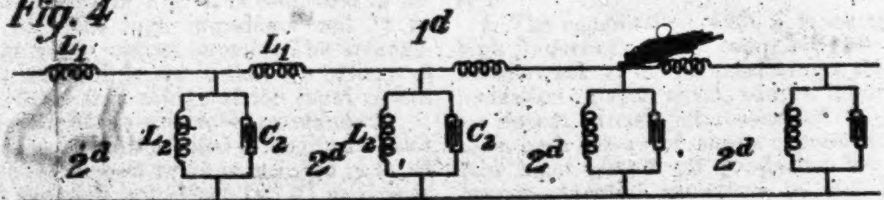
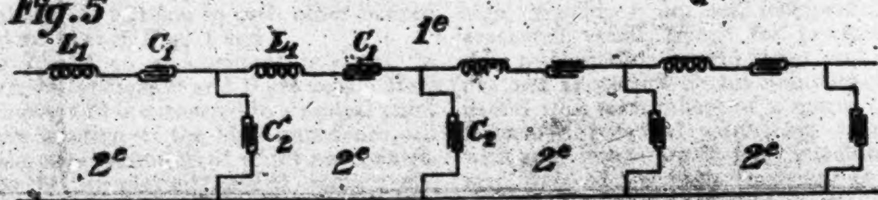


Fig. 5



Inventor:
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1473

G. A. CAMPBELL.
ELECTRIC WAVE FILTER.
APPLICATION FILED JULY 15, 1915.

1,227,113. Patented May 22, 1917.
3 SHEETS—SHEET 2.

Fig. 6

Fig. 7

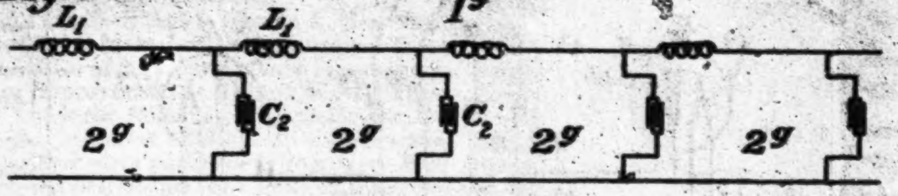


Fig. 8

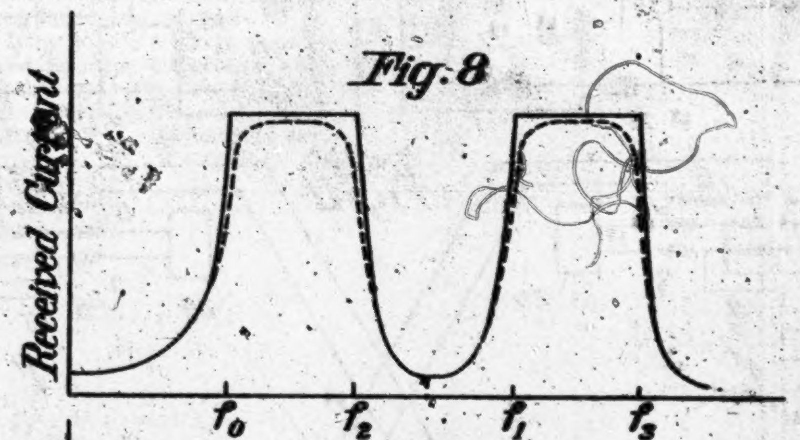
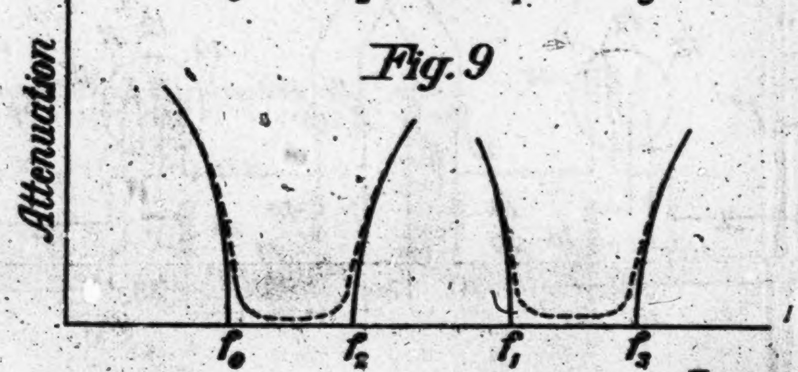


Fig. 9



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G. A. CAMPBELL.
ELECTRIC WAVE FILTER.
APPLICATION FILED JULY 15, 1915.

1,227,118.

Patented May 22, 1917.

3 SHEETS—SHEET 3.

Fig. 10

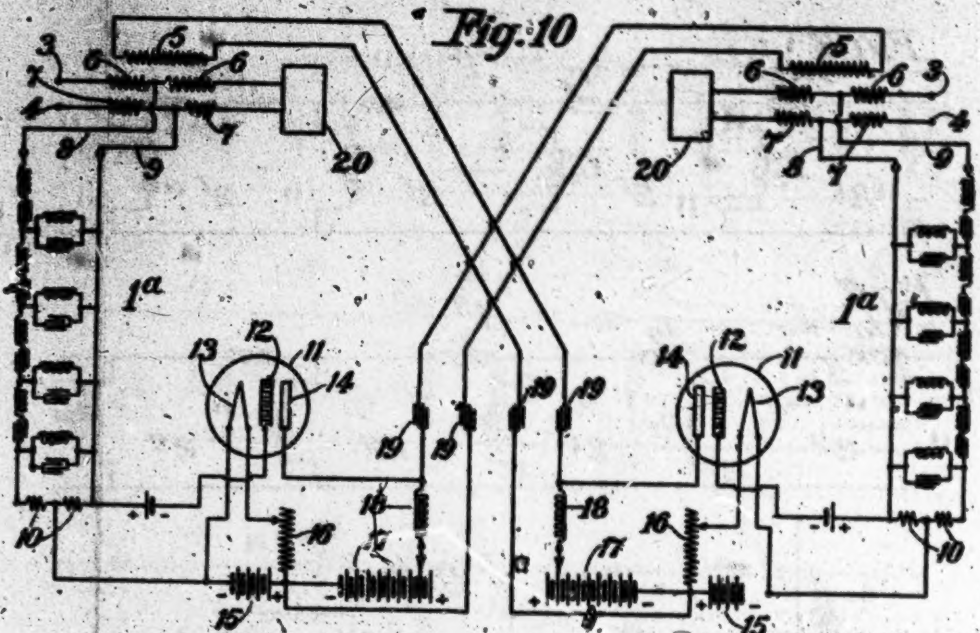
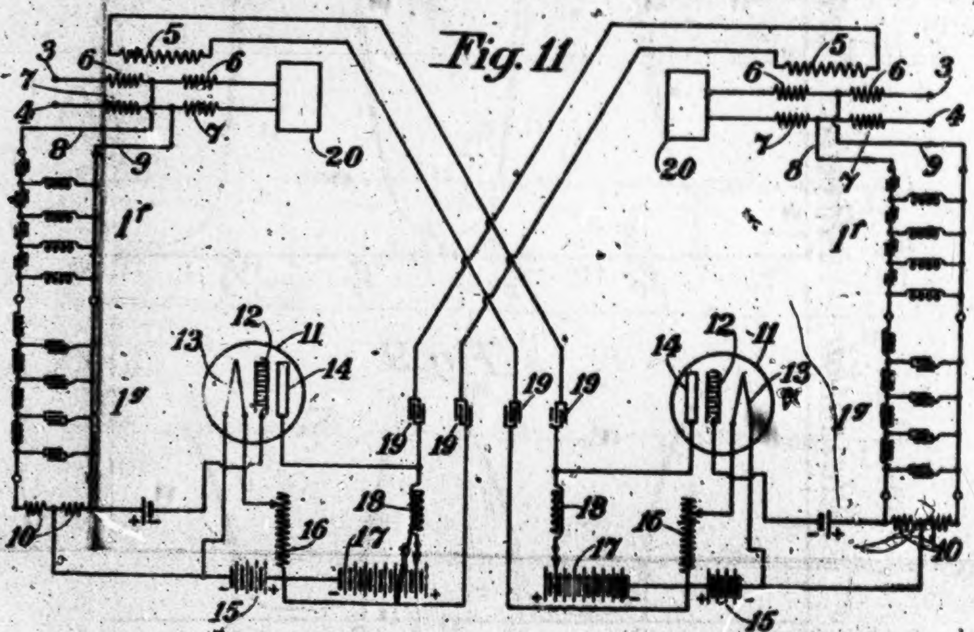


Fig. 11



Inventor:
G. A. Campbell
per Thomas D. Lockwood
Attorney

UNITED STATES PATENT OFFICE.

GEORGE A. CAMPBELL, OF MONTCLAIR, NEW JERSEY, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

ELECTRIC WAVE-FILTER.

1,227,113. Specification of Letters Patent. Patented May 22, 1917.

Application filed July 15, 1915. Serial No. 40,067.

To all whom it may concern:

Be it known that I, GEORGE A. CAMPBELL, residing at Montclair, in the county of Essex and State of New Jersey, have invented certain Improvements in Electric Wave-Filters, of which the following is a specification.

This invention relates to an electric wave-filter and more particularly to a wave-filter adapted to transmit with small or negligible attenuation sinusoidal currents of all frequencies lying within a range or ranges of preassigned limiting frequencies while attenuating and approximately extinguishing sinusoidal currents of frequencies lying outside the limits of the preassigned range or ranges.

My invention, though it may find expression in many embodiments, has common to all the broad idea of a wave-filter in the nature of a connecting line having an impedance element or elements in series with the line and an impedance element or elements in shunt across the line, the values of the impedance elements being so proportioned that the structure will transmit, with small or negligible attenuation, from a source of electromagnetic energy to an electrical receiving, translating or repeating device, sinusoidal currents of all frequencies lying within specified and preassigned limits or ranges while attenuating and sensibly extinguishing currents of all frequencies lying outside such limits.

My invention in one or more of its embodiments has important applications in connection with wireless telegraphy, wireless telephony, multiplex high frequency wire telephony, composite telegraph and telephone lines, and in particular with telephone repeater circuits, wherein it is highly important that means be provided for selecting a range or band of frequencies, such as, for instance, the range or band of frequencies necessary for intelligible telephonic transmission of speech, while at the same time excluding from the receiving or translating device currents of all other frequencies.

My invention is illustrated in the accompanying drawings in which Figure 1 is a diagram illustrating the broad form of my invention from which all specific embodiments may be derived by assigning proper values to the electrical constants of the structure; Figs. 2, 3, 4, 5, 6 and 7 are diagrams illustrating different embodiments of my invention; Figs. 8 and 9 show curves illustrating the characteristic performance of the wave-filter; and Figs. 10 and 11 are diagrams showing my invention embodied in telephone repeater circuits.

Like reference characters refer to like parts throughout the several figures of the drawings.

Referring to Figs. 1 to 7 inclusive, each wave filter 1^a, 1^b, 1^c, 1^d, 1^e, 1^f, 1^g is composed of a plurality of identical sections 2^a, 2^b, 2^c, 2^d, 2^e, 2^f, 2^g, respectively, each including lumped impedance in series with the line and lumped impedance in shunt across the line. Said impedance may be provided by condensers, C_1, C_2 or by inductance coils L_1, L_2 or by a suitable combination of both, there being at least, for each section of the wave-filter, an inductance element in series with the line and a capacity element in shunt across the line or vice versa. Thus in Fig. 1 showing the preferred embodiment of the invention, there are, for each section, both a condenser C_1 and an inductance coil L_1 in series with the line and a condenser C_2 and an inductance coil L_2 in parallel in shunt across the line. In said figures, as well as in the other figures of the drawing, the reference characters C_1 and C_2 are used to designate similar elements, that is condensers, the subscript 1 affixed to the reference letter indicating that the element is in series with the line and the subscript 2 indicating that the element is in shunt across the line. In like manner the reference characters L_1 and L_2 are used to indicate in-

ductance coils in series with the line and in shunt across the line, respectively.

In Figs. 2 to 7 inclusive, said impedance elements for each section are included as follows:—in Fig. 2 there is a condenser in series with the line and a condenser and an inductance coil in parallel in shunt across the line; in Fig. 3, a condenser and an inductance coil in series with the line and an inductance coil in shunt across the line; in Fig. 4 an inductance coil in series with the line and a condenser and an inductance coil in parallel in shunt across the line; in Fig. 5, a condenser and an inductance coil in series with the line and a condenser in shunt across the line; in Fig. 6, a condenser in series with the line and an inductance coil in shunt across the line; and, in Fig. 7, an inductance coil in series with the line and a condenser in shunt across the line. Said Figs. 1 to 7 inclusive, merely show typical forms of the invention and are not intended to illustrate all of the possible modifications thereof.

By assigning suitable values to the condensers C_1, C_2 and the inductance coils L_1, L_2 in said Figs. 1 to 7 inclusive, the structure, if inserted as a connecting line between a source of electromagnetic energy and an electrical receiving, translating or repeating device, will transmit to the latter sinusoidal currents lying within preassigned ranges or bands and will at the same time effectively protect the receiving, translating or repeating device from currents of frequencies lying outside the preassigned ranges of frequencies.

The fundamental principles underlying my invention and the manner of applying the same so as to provide a structure embodying the invention will now be set forth.

It is a well known fact that, in a uniform transmission line containing uniformly distributed resistance, inductance and capacity, the attenuation of current along the line is a phenomenon which is caused by resistance dissipation and becomes zero when the resistance becomes zero. In a periodic structure, however, containing lumped series impedance and lumped shunt impedance, high attenuation may exist even when the resistance is practically zero. This attenuation is due not to resistance dissipation but to involved reactions among the impedance units of the structure. The reactions and interactions, taking place in the structure and determining the character of the attenuation attending transmission of periodic currents, are so involved as to make desirable the use of mathematical formula in elucidating the laws governing the electromagnetic phenomena taking place in the structure and in particular in laying down rules of design whereby any one, skilled in the art, may construct the electric wave-filter of this invention.

For the purpose of deriving the mathematical formulæ pertaining to the theory of my invention, assume a structure consisting of a series of sections, each section having an impedance Z_1 in series with the line, and an impedance Z_2 in shunt across the line. Letting J_n denote the circuital current flowing in the nth section of the structure, J_{n-1} the current flowing in the $(n-1)$st section, and J_{n+1} the current flowing in the $(n+1)$st section, and applying Kirchhoff's law to said currents and circuits, it follows that:—

$$Z_1 J_n + Z_2(J_n - J_{n+1}) + Z_2(J_n - J_{n-1}) = 0.$$

By various rearrangements this equation may be written as,

$$\frac{J_{n+1}}{J_n} + \frac{J_{n-1}}{J_n} = \frac{Z_1}{Z_2} + 2.$$

The last foregoing equation is a difference equation and, under the principles of the calculus of finite differences, the ratio of

$$\frac{J_{n+1}}{J_n}$$

is equal to the ratio of

$$\frac{J_n}{J_{n-1}},$$

the equality of said ratio holding for propagation in either direction. If this ratio is set equal to ϵ^{Γ} without specifying the value of Γ, it follows that for propagation in either direction:

$$\frac{J_{n+1}}{J_n} = \epsilon^{\Gamma} \text{ and } \frac{J_{n-1}}{J_n} = \epsilon^{-\Gamma} \quad (1)$$

In the foregoing equations, ϵ denotes the base of Naperian logarithms, and Γ denotes the propagation constant of the structure. The value of Γ is, so far, unknown but may be determined by substitution of the above values of

$$\frac{J_{n+1}}{J_n}$$

and

$$\frac{J_{n-1}}{J_n},$$

in the above difference equation, whence,

$$\epsilon^{\Gamma} + \epsilon^{-\Gamma} = \frac{Z_1}{Z_2} + 2$$

or,

$$\cosh \Gamma = \frac{1}{2}\left(\frac{Z_1}{Z_2}\right) + 1 \quad (2)$$

Referring to equation (1), if Γ is not a pure imaginary, the current value is dimin-

ished or attenuated in transmission from the nth section to the $(n+1)$st section. If Γ is a pure imaginary, the absolute values of J_n and $J_{(n+1)}$ are equal, and hence the current suffers no attenuation in transmission from section to section but only a change of phase. The condition, then, for unattenuated transmission is that Γ shall be a pure imaginary. It may be shown from equation (2) that the condition for unattenuated transmission is that

$$\frac{1}{2}\left(\frac{Z_1}{Z_2}\right)+1 \text{ shall lie between } \pm 1. \quad (3)$$

Hence the limiting values of the frequency for free transmission are given by:—

$$\left.\begin{aligned} \frac{Z_1}{Z_2}&=0 \\ Z_1&=-4Z_2 \end{aligned}\right| \quad (4)$$

For the structure shown in Fig. 1, it is evident that the series impedance,

$$Z_1=\frac{1-L_1C_1p^2}{ipC_1};$$

and the shunt impedance

$$Z_2=\frac{iL_2p}{1-L_2C_2p^2}.$$

In these formulæ p is $2\pi f$ where f is the frequency in cycles per second, and i is the imaginary quantity

$$\sqrt{-1}.$$

Referring to the expressions for Z_1 and Z_2 above given, it is evident that equations (4) have as the variable or unknown the value of p. There are four roots or four values of p which will satisfy said equations (4), which roots will be denoted by the symbols p_0, p_1, p_2 and p_3. Said roots have the following values:—

$$p_3=\frac{1}{\sqrt{2L_1C_2}}\sqrt{4+\frac{L_1}{L_2}+\frac{C_2}{C_1}+\sqrt{\left(4+\frac{L_1}{L_2}+\frac{C_2}{C_1}\right)^2-4\frac{L_1C_2}{L_2C_1}}} \quad (5)$$

$$p_0=\frac{1}{\sqrt{2L_1C_2}}\sqrt{4+\frac{L_1}{L_2}+\frac{C_2}{C_1}-\sqrt{\left(4+\frac{L_1}{L_2}+\frac{C_2}{C_1}\right)^2-4\frac{L_1C_2}{L_2C_1}}} \quad (6)$$

$$p_1=\frac{1}{\sqrt{L_1C_1}} \quad (7)$$

$$p_2=\frac{1}{\sqrt{L_2C_2}}. \quad (8)$$

It will be observed that these four limiting values of p or $2\pi f$ are in geometrical proportion, and that:—

$$\frac{p_3}{p_1}=\frac{p_2}{p_0} \quad (9)$$

An examination of equations (4) to (9) inclusive shows that the unattenuated frequencies lie in two distinct, continuous bands or ranges. If $p_1>p_2$, the frequencies of unattenuated transmission lie between $p_3/2\pi$ and $p_1/2\pi$ for the upper band and between $p_2/2\pi$ and $p_0/2\pi$ for the lower band. If, on the contrary, $p_1<p_2$, the frequencies for the upper band lie between $p_3/2\pi$ and $p_2/2\pi$, and for the lower band between $p_1/2\pi$ and $p_0/2\pi$.

Equations (5) to (9) inclusive are fundamental to my invention and by their aid the electrical constants of the wave-filter of my invention may be determined. From said fundamental equations, simplified formulæ for different structural embodiments of the invention may be derived, as will hereinafter be pointed out.

Referring to the drawings, Figs. 8 and 9 show the character of transmission through the structure illustrated in Fig. 1. In said Figs. 8 and 9, f_0, f_2, f_1, f_3, represent frequencies corresponding to p_0, p_2, p_1, p_3, respectively. In Fig. 8, the ordinates are received currents while the abscissæ are frequencies. Fig. 9 has as its ordinates attenuation values per section and as abscissæ frequencies. The full line curves refer to the ideal structure in which the resistance of the impedance units is quite negligible, while the broken line curves show the departure from the ideal case due to resistance in the structure. In any case the resistances are made sufficiently small to be practically negligible.

It is not always desirable to transmit two bands of frequencies, and as a further refinement, my invention also contemplates a wave-filter which will transmit freely all frequencies lying within a single band of specified limits. As will hereinafter be more fully set forth, the structures shown in Figs. 2 to 7 inclusive will function as a single band wave-filter, and the structure shown in Fig. 1 may be made to so function.

Reference to Fig. 8 and to equations (5), (6), (7) and (8), shows clearly that if the two bands of free transmission are made to coalesce or merge into one by setting $f_1=f_2$, or if one of the bands is pushed out or relegated either to infinity or to zero, there remains one single band of free transmission for finite frequencies. The first form of single band wave-filter is attained by mak-

ing $f_1=f_2$ or $L_1C_1=L_2C_2$. This form will be referred to as a filter having coalescent or confluent bands.

The second method of realizing a single band wave-filter is attained by relegating the upper band to infinity or the lower band to zero. Reference to equations (5), (6), (7) and (8), shows that one band is relegated to infinity if L_1 or $C_2=0$; while the other band is relegated to zero if L_2 or $C_1=\infty$. Obviously, from the foregoing, the single band may also be attained by making $L_1=C_2=0$, or by making $L_2=C_1=\infty$. It will be understood, of course, that an infinite inductance or a zero capacity are equivalent to an infinite impedance, and, hence, a circuit through the same may be regarded as replaced by an open circuit; on the other hand a zero inductance or an infinite capacity are equivalent to a zero impedance, and, hence, they may be regarded as in effect short circuited.

It thus appears that there are, in general, seven ways of reducing the double band wave-filter to a single band wave-filter, namely:

(*a*) Making the two broad bands coalescent or confluent by setting $L_1C_1=L_2C_2$;

(*b*) Relegating one band to infinity by making $L_1=0$;

(*c*) Relegating one band to infinity by making $C_2=0$;

(*d*) Relegating one band to zero by making $C_1=\infty$;

(*e*) Relegating one band to zero by making $L_2=\infty$.

(*f*) Making $L_1=C_2=0$ and thereby transmitting freely all frequencies above a specified value;

(*g*) Making $L_2=C_1=\infty$ and thereby transmitting all frequencies below a specified value.

Design formulæ will now be given by applying which any one skilled in the art may construct a wave-filter which will freely transmit a definite, preassigned band or definite, preassigned bands of frequencies while attenuating all frequencies lying outside these bands.

Considering first the general form of the double band wave-filter, let it be required to design a filter which shall freely transmit all frequencies lying between the limiting frequencies f_3 and f_2 and also between f_1 and f_0 with the provision that

$$f_3>f_2>f_1>f_0$$

and

$$\frac{f_2}{f_1}=\frac{f_3}{f_0}.$$

The formulæ determining the relations obtaining among the electrical constants are deducible from equations (5), (6), (7) and (8), and are as follows:—

$$L_1C_1=\left(\frac{1}{2\pi f_1}\right)^2 \qquad \text{(I)}$$

$$L_2C_2=\left(\frac{1}{2\pi f_2}\right)^2 \qquad \text{(II)}$$

$$\frac{L_2}{L_1}=\frac{1}{4}\left(\frac{f_1}{f_0}\right)^2\left[1-\left(\frac{f_0}{f_1}\right)^2\right]\left[1-\left(\frac{f_0}{f_2}\right)^2\right] \qquad \text{(III)}$$

or

$$\frac{L_2}{L_1}=\frac{1}{4}\left(\frac{f_3}{f_2}\right)^2\left[1-\left(\frac{f_3}{f_1}\right)^2\right]\left[1-\left(\frac{f_3}{f_2}\right)^2\right] \qquad \text{(IV)}$$

Formulæ III and IV are equivalent. A structure so designed or proportioned that its electrical constants satisfy formulæ (I), (II) and (III), or (I), (II) and (IV), complies with the above stated requirements for freely transmitting frequencies lying between f_3 and f_2, constituting one band and between f_1 and f_0, constituting the second band, while attenuating and sensibly extinguishing currents of all frequencies lying outside these bands.

The rules of design of the single band wave-filter will now be considered, the different cases, hereinbefore stated, being treated in order.

(*a*) Confluent bands, in which case $L_1C_1=L_2C_2$. This form is shown in Fig. 1, it being understood that the structure shown in said figure may be made to function as a single band wave-filter by making $L_1C_1=L_2C_2$, that is by causing the two bands to coalesce. If the frequencies to be freely transmitted are to lie between the upper limiting frequency f_3 and the lower limiting frequencies f_0, the design formulæ are:

$$L_1C_1=L_2C_2=\left(\frac{1}{2\pi f_3}\right)\left(\frac{1}{2\pi f_0}\right) \qquad \text{(I}^a\text{)}$$

$$\frac{L_2}{L_1}=\frac{1}{4}\left(\frac{f_0}{f_3}\right)\left(\frac{f_3}{f_0}-1\right)^2 \qquad \text{(II}^a\text{)}$$

(*b*) Relegating one band to infinity by making $L_1=0$ in which case the structure of the wave-filter assumes the form shown in Fig. 2. If the limiting frequencies of free transmission are f_3 (upper limit) and f_0 (lower limit), the design equations for this form are:—

$$L_2C_2=\left(\frac{1}{2\pi f_3}\right)^2 \qquad \text{(I}^b\text{)}$$

$$\frac{C_1}{C_2}=\frac{1}{4}\left[\left(\frac{f_3}{f_0}\right)^2-1\right] \qquad \text{(II}^b\text{)}$$

(*c*) Relegating one band to infinity by making $C_2=0$, in which case the structure of the wave-filter assumes the form shown in Fig. 3. If the limiting frequencies of free transmission are f_1 (upper limit) and f_0

(lower limit) the design formulæ for this form are:—

$$L_1C_1=\left(\frac{1}{2\pi f_1}\right)^2 \qquad (I^c)$$

$$\frac{L_2}{L_1}=\frac{1}{4}\left[\left(\frac{f_1}{f_0}\right)^2-1\right] \qquad (II^c)$$

(*d*) Relegating one band to zero by making $C_1=\infty$, in which case the wave-filter is of the form shown in Fig. 4. Let the limiting frequencies be f_3 and f_2 and the design formulæ are:

$$L_2C_2=\left(\frac{1}{2\pi f_2}\right)^2 \qquad (I^d)$$

$$\frac{L_2}{L_1}=\frac{1}{4}\left[\left(\frac{f_3}{f_2}\right)^2-1\right] \qquad (II^d)$$

(*e*) Relegating one band to zero by making $L_2=\infty$, in which case the wave-filter assumes the form shown in Fig. 5. Let the limiting frequencies of free transmission be f_3 and f_1 and the design formulæ are:

$$L_1C_1=\left(\frac{1}{2\pi f_1}\right)^2 \qquad (I^e)$$

$$\frac{C_1}{C_2}=\frac{1}{4}\left[\left(\frac{f_3}{f_1}\right)-1\right] \qquad (II^e)$$

(*f*) Making $L_2=C_2=0$, in which case the wave-filter assumes the form shown in Fig. 6 and freely transmits all frequencies above a definite inferior limit. If the inferior limit is specified as f_0, the design formula is:

$$L_2C_1=\frac{1}{4}\left(\frac{1}{2\pi f_0}\right)^2 \qquad (I^f)$$

(*g*) Making $L_2=C_1=\infty$, in which case the wave-filter assumes the form shown in Fig. 7 and freely transmits all frequencies below a specified superior limit. If the superior limiting frequency is specified as f_2, the design formula is:

$$L_1C_2=4\left(\frac{1}{2\pi f_2}\right)^2 \qquad (I^g)$$

It will be observed from the foregoing design formulæ that there is always one impedance element whose value is a matter of choice. The value of this element may be determined from convenience of design or may be made to satisfy some other specified requirement, such as, for instance, that the line shall have a definite impedance at a particular frequency. It is further evident that the particular form of single band wave-filter is a matter of choice and the selection of any particular form may be left to the requirements of a particular design.

It will further be understood that the number of sections of the wave-filter will depend on the degree to which it is desired to extinguish the currents to be filtered out. If the number of sections is doubled the ratio of the current of any particular frequency entering the filter to the current of that frequency leaving the filter is approximately squared.

It should be clearly understood that my invention differs fundamentally both in structure and function from loaded transmission line systems. In transmission lines in which loading coils may advantageously be inserted, the attenuation is excessive and the sole purpose and object of loading is to reduce the attenuation which normally exists in the unloaded line. Moreover said organizations are strictly dependent for their utility upon the proper spacing of the loading elements such as inductance coils or condensers with reference to the electrical wave length of the line. In the present invention, however, the line in which the impedance elements are inserted is so short that normally the attenuation is absolutely negligible, that is, there is no observable attenuation except when the impedance elements are inserted in accordance with my invention. When, however, the impedance elements are so inserted, the normally non-attenuating line sharply attenuates currents of preassigned frequencies while freely transmitting currents of other frequencies. My invention is therefore not concerned with the spacing of the impedance elements with reference to the electrical wave length since said entire line is so short as normally to extend over only a minute fraction of a wave length, but is directed to the proper proportioning of said impedance elements. In brief my invention is directed to introducing in a line normally of negligible attenuation, impedance elements so proportioned as to render said line attenuating for certain specified or preassigned ranges of frequencies.

As an example of the application of the foregoing design formulæ, let it be required to design a filter which shall transmit all frequencies lying between 200 and 2000 cycles per second. Any one of the forms shown in Figs. 1, 2, 3, 4, 5 may be employed or the two forms shown in Figs. 6 and 7 connected in series. Let it be assumed that convenience or other considerations lead to the selection of the type of wave-filter shown in Fig. 1. Applying design formulæ (I^a) and (II^a), applicable to this type of single band wave-filter, and substituting therein for f_1 and f_2 the above assigned values 200 and 2000, respectively:

$$L_1C_1=L_2C_2=\left(\frac{1}{2\pi 2000}\right)\left(\frac{1}{2\pi 200}\right)=(.635)\,10^{-7}$$

and

$$\frac{L_2}{L_1}=\frac{1}{4}\left(\frac{200}{2000}\right)\left(\frac{2000}{200}-1\right)^2=2.025$$

Therefore the above stated requirements are satisfied if

$$L_1C_1=L_2C_2=(.635)\,10^{-7}$$

and

$$\frac{L_2}{L_1}=2.025.$$

As has been hereinbefore stated, one of the constants L_1, C_1, L_2, C_2 is arbitrary. Let it be assumed that convenience or other considerations dictate a value of 1 henry for L_2. The values of the several impedance elements are then as follows: $L_2=1$ henry; $L_1=0.494$ henry; $C_1=(1.29)\,10^{-7}=0.129$ microfarad; and $C_2=0.0635$ microfarad.

Therefore the wave-filter shown in Fig. 1 having its impedance elements of the values above derived will transmit freely currents of all frequencies lying between 200 and 2000 cycles per second. The attenuation constant per section at a frequency of 2200 cycles per second, for example, is found from equation (2) by computation to be .98. Hence, from equation (1), the ratio of currents in adjacent sections is 2.67 approximately, and if five sections are employed the current of 2200 cycles in the 5th section is less than 2% of its value in the first section, while currents of frequency lying between 200 and 2000 cycles per second are practically unattenuated.

Fig. 10 shows my invention, as embodied in the type shown in Fig. 1, employed in combination with vacuum tube repeater circuits. It is to be understood that the embodiments of my invention shown in Figs. 2, 3, 4 and 5 might be equally well employed. In said Fig. 10, a two-way two-repeater set consisting of two symmetrical halves is shown, and hence the same parts in the two halves of the set are designated by the same reference characters. The terminals 3, 4 and 3, 4 connect the repeater set in series with the through telephone line (not shown). At each end of the set are the secondary windings 6, 6 and 7, 7 of a repeating coil, of which the windings 5 constitute the primaries. Across the middle of the windings 6, 6 and 7, 7 are connected the conductors 8, 9 which lead to the filters 1^a. The other end of each filter is closed by a non-inductive resistance 10. The vacuum tube repeaters 11 are of a well-known type comprising a grid 12, filament 13, and plate 14. The input side of the repeater 11 is shown as bridged across half of the non-inductive resistance 10. The battery 15 heats the filament 13 through the adjustable resistance 16. Across the filament 13 and plate 14 is bridged the battery 17 in series with the high inductance coil 18. The function of the coil 18 is to allow the passage of direct current, but to prevent the passage of alternating current of telephonic frequencies. In parallel with the battery 17 and inductance coil 18, the repeater coil primary 5 is connected through the condensers 19, 19 whose function is to prevent the passage of direct current through the winding 5. Artificial lines 20, 20, which may be of a well-known construction, are provided, said artificial lines having substantially the same impedance as the telephone line over the range of telephonic frequencies. Said artificial lines are provided in order that inductive effects from the output side of one repeater 11, impressed through the coil 5, shall not create any difference of potential between the conductors 8 and 9. This condition is necessary in order that the output side of one repeater shall not impress disturbances on the input side of the other repeater, and thus cause sustained interaction or "singing" between the repeaters 11, 11. The function of the filters 1^a, 1^a is to prevent currents other than those necessary for the telephonic transmission of intelligible speech from being transmitted from the telephone line to the input side of the repeaters 11, 11.

The repeater set shown in Fig. 11 is the same as that shown in Fig. 10 except as to the form of the wave-filter. In said Fig. 11, the wave-filter structure consists of a low frequency wave-filter 1^f and a high frequency wave-filter 1^g of the types shown in Figs. 6 and 7, respectively, connected in series. The advantage of this latter structure over that shown in Fig. 10 is that the low frequency wave-filter 1^f may be omitted from the circuit when conditions are such as not to require the protection of the repeater from low frequency disturbances.

It is well known that high frequency induction or inductive disturbances militate seriously against the satisfactory operation of telephone repeaters, particularly of the vacuum tube type, such as are shown in Figs. 10 and 11. It is also well known that low frequency disturbances, such as those due to superposed or composited telegraphic impulses are equally objectionable. My invention prevents either high frequency or low frequency disturbances from affecting the repeater by inserting wave-filters between the telephone lines and the repeaters, as shown, for example, in Figs. 10 and 11. In this particular case, said wave-filters are designed to transmit all frequencies lying within the limiting frequencies, say between 200 and 2200 cycles per second, necessary for intelligible telephonic transmission of

ech, while extinguishing currents of all quencies lying above 2200 and below 200 les per second.

A further advantage attending the employment of the wave filter with the repeater cuits lies in the fact that the balancing ificial line need simulate the impedance racteristics of the telephone lines only r the limited range of frequencies necesy for intelligible telephonic transmission speech, which permits of a more simple, cient, and economical artificial line.

The invention which consists in the corative combination of the wave filter of invention with a repeater, as illustrated Figs. 10 and 11, is not embodied in the ended claims, but forms the subject mat of my co-pending application, Serial 101,845, filed June 5, 1916.

claim:—

An electric wave-filter consisting of a necting line of negligible attenuation taining lumped impedance in series with line and lumped impedance in shunt ss the line, said impedances having preputed values dependent upon the upper iting frequency and the lower limiting quency of a range of frequencies it is ded to transmit without attenuation, the es of said series and shunt impedances g so proportioned that the structure smits with practically negligible attenon sinusoidal currents of all frequencies g between said two limiting frequencies, le attenuating and approximately exuishing currents neighboring frequen lying outside of said limiting frequen-

An electric wave-filter consisting of a necting line of negligible attenuation posed of a plurality of sections, each sec including a capacity element and an ctance element, one of said elements of section being in series with the line and other in shunt across the line, said caty and inductance elements having preputed values dependent upon the upper ting frequency and the lower limiting uency of a range of frequencies it is del to transmit without attenuation, the es of said capacity and inductance eles being so proportioned that the struc transmits with practically negligible uation sinusoidal currents of all freies lying between said two limiting frecies, while attenuating and approxily extinguishing currents of neighbor requencies lying outside of said limiting encies.

An electric wave-filter consisting of a ecting line of negligible attenuation containing lumped capacity in series with the line and lumped inductance in shunt across the line, said capacity and said inductance having precomputed values dependent upon the upper limiting frequency and the lower limiting frequency of a range of frequencies it is desired to transmit without attenuation, the values of said capacity and inductance being so proportioned that the structure transmits with practically negligible attenuation sinusoidal currents of all frequencies lying between said two limiting frequencies, while attenuating and approximately extinguishing currents of neighboring frequencies lying outside of said limiting frequencies.

4. An electric wave-filter consisting of a line composed of a plurality of sections, each section including a condenser and an inductance coil in series with the line, and an inductance coil in shunt across the line, said condensers and inductance coils having precomputed values dependent upon the upper limiting frequency and the lower limiting frequency of a range of frequencies it is desired to transmit without attenuation, the values of said condensers and said inductance coils being so proportioned that the structure transmits with practically negligible attenuation sinusoidal currents of all frequencies lying between said two limiting frequencies, while attenuating and approximately extinguishing currents of neighboring frequencies lying outside of said limiting frequencies.

5. An electric wave-filter consisting of a line composed of a plurality of sections, each section including a condenser in series with the line and an inductance coil and a condenser in parallel in shunt across the line, said condensers and inductance coils having precomputed values dependent upon the upper limiting frequency and the lower limiting frequency of a range of frequencies it is desired to transmit without attenuation, the values of said condensers and said coils being so proportioned that the structure transmits with practically negligible attenuation sinusoidal currents of all frequencies lying between said two limiting frequencies while attenuating and approximately extinguishing currents of neighboring frequencies lying outside of said limiting frequencies.

6. An electric wave-filter consisting of a line composed of a plurality of sections, each section having a condenser and an inductance coil in series with the line and a condenser and an inductance coil in parallel in shunt across the line, said condensers and inductance coils having precomputed values

dependent upon the upper limiting frequency and the lower limiting frequency of a range of frequencies it is desired to transmit without attenuation, the values of said condensers and said coils being so proportioned that the structure transmits with practically negligible attenuation sinusoidal currents of all frequencies lying between said two limiting frequencies while attenuating and approximately extinguishing neighboring frequencies lying outside of said limiting frequencies.

In testimony whereof, I have signed my name to this specification in the presence of two subscribing witnesses, this ninth day of July 1915.

GEORGE A. CAMPBELL.

Witnesses:

George E. Folk,

John R. Carson.

Certificate of Correction.

It is hereby certified that in Letters Patent No. 1,227,113, granted May 29, 1917, upon the application of George A. Campbell, of Montclair, New Jersey, for an improvement in "Electric-Wave Filters," an error appears in the printed specification requiring correction as follows: Page 5, below line 26, for formula (II^{a})—

$$\frac{C_2}{C_1}=\frac{1}{4}\left[\left(\frac{f_2}{f_1}\right)-1\right] \text{ read } \frac{C_2}{C_1}=\frac{1}{4}\left[\left(\frac{f_2}{f_1}\right)^2-1\right]$$

and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 9th day of October, A. D., 1923.

[SEAL.]

WM. A. KINNAN,

Acting Commissioner of Patents.

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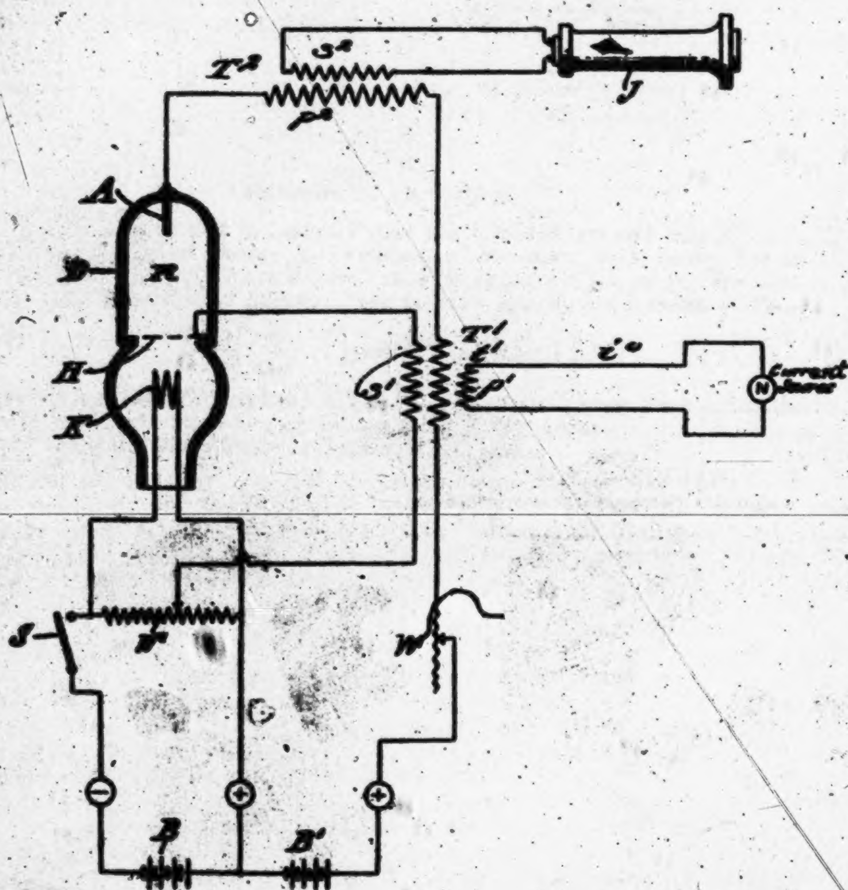
1483

E. REISZ.

PROCESS TO INCREASE THE SENSIBILITY OF RELAYS FOR ALTERNATING CURRENTS.

APPLICATION FILED APR. 9, 1913.

1,234,489. Patented July 24, 1917.



Witnesses,
G. E. Kesler
Chas. S. Hoyer.

Inventor
Eugen Reisz
by
Morris L. Norris,
Attorney

UNITED STATES PATENT OFFICE.

EUGEN REISZ, OF BERLIN-TREPTOW, GERMANY.

PROCESS TO INCREASE THE SENSIBILITY OF RELAYS FOR ALTERNATING CURRENTS.

1,234,489. Specification of Letters Patent. Patented July 24, 1917.

Application filed April 9, 1913. Serial No. 760,094.

To all whom it may concern:

Be it known that I, EUGEN REISZ, a subject of the Emperor of Austria, residing at Berlin-Treptow, Germany, have invented certain new and useful Improvements in Processes to Increase the Sensibility of Relays for Alternating Currents, of which the following is a specification.

This invention relates to a method of increasing the sensibility of relays for alternating currents of a determined number of periods so that the currents reinforced react directly or inductively upon the relays. In this connection, it is presumed that alternating currents with simple curve form, for instance, sine currents, are to be reinforced. The method can only be employed when the relay has no mechanical inertia at all, as is the case, for instance, in gas discharging relays, as otherwise the self-oscillation of the apparatus would frustrate the effect just explained. In the drawing an apparatus is shown wherein the method may be effectively carried out, and therein an embodiment of the invention is represented in diagrammatic form.

Referring to the drawing, R is the relay consisting of a discharge tube D having a heated cathode K and an anode A between which an auxiliary electrode H of sieve or net form is arranged. A battery B provides the heating current for the cathode and a second battery B^1 the current for the tube. The auxiliary electrode is connected to the battery B by the adjustable resistance W^1. Two transformers T^1 and T^2 inductively connect the line N or other source of currents to be reinforced with the relay circuit and the latter circuit with the receiving instrument J respectively. The transformer T^1 consists of three windings p^1, s^1 and s^2; the winding p^1 is the primary of the transformer and is connected with the source N of the currents to be reinforced, for instance with the antenna; s^1 is the secondary winding cut into the circuit of the auxiliary electrode. The third winding s^2 of the transformer T^1 is arranged in the circuit which contains the anode A and the primary winding p^2 of the second transformer T^2. An adjustable resistance W is furthermore arranged in this circuit and prevents the generation of a continuous alternating current in said circuit and at the same time regulates the current flowing through the discharge tube. The terminals of the secondary winding s^3 of the transformer T^2 and the receiving instrument J, for instance a telephone, are connected. The source of the alternating current to be reinforced acts inductively through the auxiliary winding s^1, as above noted, upon the auxiliary electrode. The anode currents reinforcibly released in this manner flow through the winding p^2 and induce currents in the telephone and through the winding s^2 again influence the auxiliary electrode whereby a further increase of the anode current results. When the electric constants of coils T^1 and T^2 are selected in such manner that the currents reacting upon the relay coincide in their direction with the primary current, that is, when there is no shifting of phases present between the primary and secondary currents, then the amplitudes of the currents reinforced by the relay always become greater. The strength of these currents can be adjusted through the non-inductive resistance W cut into the anode circuit to the desired value. The resistance W also prevents the appearance of a continuous alternating current through the mutual induction of the windings s^1 and s^2.

The current i^p coming from the line or other source of alternate current flows through the winding p^1 of the transformer T^1 and induces similar currents in the windings s^2 and s^1. The impulses in the circuit through s^2 are so timed that the current in s^1 is continually augmented, or the current induced in s^1 is in phase with the current induced in s^1 from p^1. The two circuits through the tube R are in resonance with each other and the capacity of the coils is relied upon to effect this tuning of the circuits.

What is claimed is:—

1. In a relay system comprising a relay without inertia, a line circuit, an actuating circuit for said relay containing the currents to be reinforced and a local relay circuit containing the reinforced currents, the two last-named circuits being adjusted to resonance, each of the circuits being provided with a winding and all the windings acting inductively on the other windings.

2. In a relay system comprising a relay without inertia, a line circuit, an actuating circuit for said relay containing the currents to be reinforced and a relay circuit containing the reinforced currents, means to establish resonance between the two last

named circuits, a transformer comprising a winding embodied in the relay circuit, a second winding embodied in the actuation circuit and a third winding embodied in the line circuit, all windings being capable of exercising an inductive action on the others, and a second transformer comprising a winding embodied in the relay circuit and a second winding connected with a receiving instrument.

3. In a relay system comprising a relay without inertia, a line circuit, an actuating circuit for said relay containing the currents to be reinforced and a relay circuit containing the reinforced currents, means to establish resonance between the two last named circuits, a transformer comprising a winding embodied in the actuating circuit of the relay and a second winding embodied in the relay circuit, both windings being capable of acting inductively on each other, the self-induction of both being so established that the currents induced in the first named winding by the other winding have a phase displacement of 90° relatively to the inducing currents.

4. In a relay system comprising a gas discharge relay having a cathode, an anode and an auxiliary electrode, a line circuit carrying alternating currents of simple curve form, an actuating circuit for the relay connected with the auxiliary electrode of the same, and a relay circuit connected with the anode and cathode of the relay, means to establish resonance between the two last named circuits, a transformer comprising a winding embodied in the line circuit, a second winding embodied in the circuit of the auxiliary electrode, and a third winding embodied in the circuit of the anode, all the windings being arranged to act inductively on each other, the self-induction of the second and third of these windings being so established that the currents induced in the second winding by the current in the third winding have a phase displacement of 90° relatively to the inducing currents and a second transformer comprising a winding embodied in the anode circuit and a winding connected with a receiving instrument.

In testimony whereof I have hereunto set my hand in presence of two subscribing witnesses.

EUGEN REISZ.

Witnesses:

SIEGMUND STRAUSS,

LUDWIG ZWEIN.

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PAGE

1486

E. H. COLPITTS.

SYSTEM FOR THE TRANSMISSION OF INTELLIGENCE.

APPLICATION FILED APR. 9, 1912.

Reissued Oct. 23, 1917. 14,380.

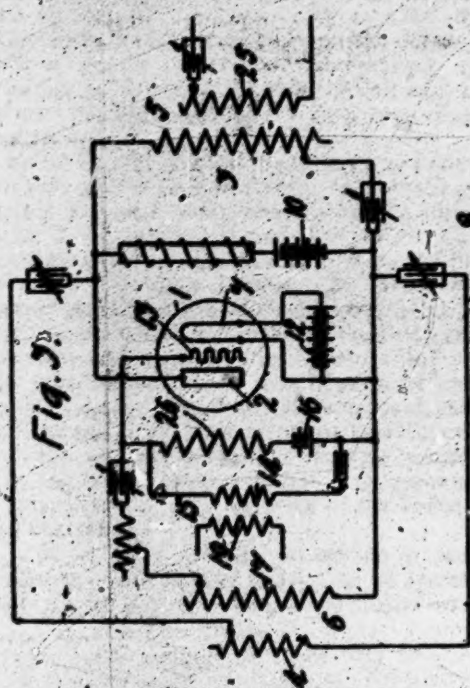

Fig. 3.

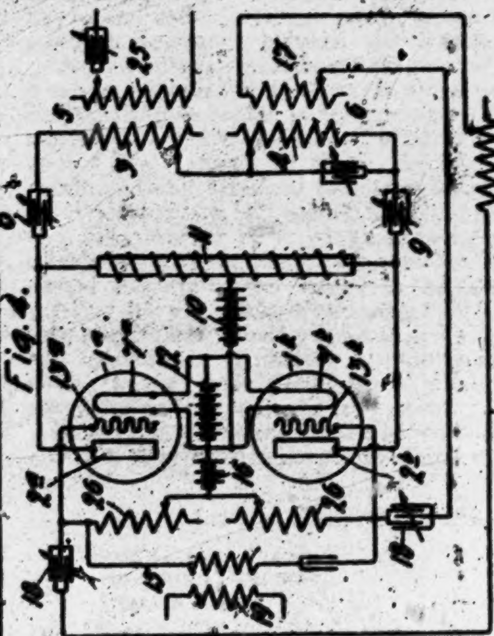

Fig. 4.

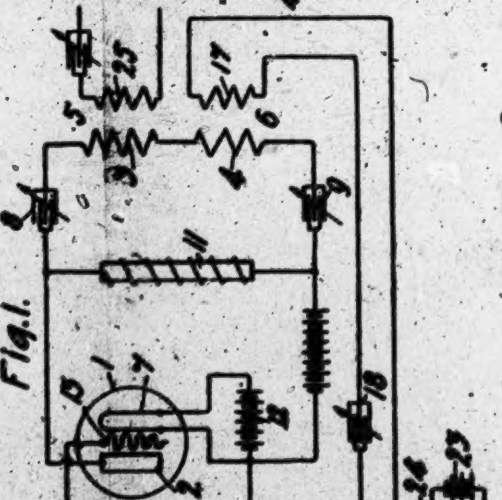

Fig. 1.

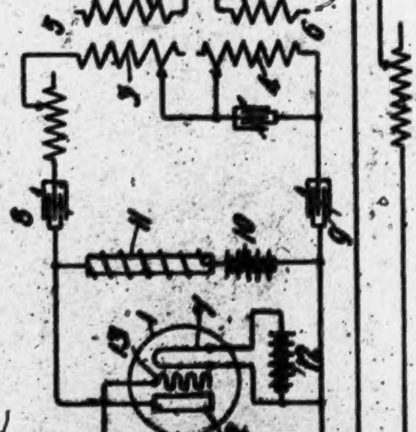

Fig. 2.

Inventor:
Edwin H. Colpitts.

by J. G. Roberts
Att'y.

UNITED STATES PATENT OFFICE.

EDWIN H. COLPITTS, OF EAST ORANGE, NEW JERSEY, ASSIGNOR, BY MESNE ASSIGNMENTS, TO AMERICAN TELEPHONE & TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

SYSTEM FOR THE TRANSMISSION OF INTELLIGENCE.

14,380. Specification of Reissued Letters Patent. Reissued Oct. 23, 1917.

Original No. 1,137,384, dated April 27, 1915, Serial No. 838,318, filed May 13, 1914. Application for reissue filed April 9, 1917. Serial No. 160,871.

To all whom it may concern:

Be it known that I, EDWIN H. COLPITTS, a subject of the King of Great Britain, residing at East Orange, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Systems for the Transmission of Intelligence.

This invention relates to systems for the transmission of intelligence, in which the amplitudes of successive electrical oscillations of high frequency are varied in accordance with the lower frequency forms of the message delivered.

Its object is to simplify the mechanism and to strengthen the effectiveness of the apparatus required for the production of the modulated oscillations.

To these ends the invention embodies a repeater which serves not only as a generator of high frequency oscillations, but also as a means for modulating the oscillations in accordance with the low frequency signaling impulses to be transmitted.

The invention is adapted for embodiment in systems of wireless telegraphy and telephony in so-called high frequency wired systems, and in general wherever a receiving device is rendered sensitive to signaling impulses or waves of low frequencies by means of sustained electric or electromagnetic waves of high frequency transmitted from the sending station.

The single device used to perform the two functions referred to may be a repeater, preferably a repeater of the audion type, wherein the output circuit is connected with the input circuit, this arrangement, with proper adjustment of devices in the circuit, resulting in the production of sustained high frequency oscillations. By varying the potential in the input circuit, as for example by connecting a transmitter or other device for sending a message in circuit with one of the electrodes, say the grid, of the audion, the sustained oscillations, it has been found, are then modulated in accordance with the message to be sent. The message may be received or recorded in any desired manner at the distant station.

Several embodiments of the invention will be set forth in the following detail description taken in connection with the accompanying drawings, wherein—

Figure 1 illustrates a system of circuits embodying the invention; and Figs. 2, 3 and 4 are modified circuits therefor.

Like parts are designated alike in the several figures.

Referring first to Fig. 1, an audion 1, the elements of which are inclosed in an evacuated vessel, as usual, is arranged with its output anode or plate 2 connected through the primary windings 3 and 4 of repeating coils 5 and 6 to the negative terminal of the heated filament or cathode 7 of the audion. Included in this output circuit may be located a battery 10 and, as required, adjustable devices such as the condensers 8 and 9. Bridged across the circuit, to feed battery current to the plate 2, is a coil of high impedance 11. The filament 7 is heated by current from the battery 12. The input electrode or grid 13 of the audion is connected through the secondary winding 14 of a repeating coil 15 to the negative terminal of the filament 7, and included in this, the input circuit, there may be located a battery 16. The secondary winding 17 of the repeating coil 6 is connected through an adjustable condenser 18 with the input circuit, one wire leading to the grid 13 and the other wire to the negative terminal of the filament 7.

The primary winding 19 of the repeating coil 15 may be connected in circuit with the secondary winding 20 of another repeating coil 21, the primary winding 22 of which is connected in circuit with a battery 23 and a sending device, which, as shown, may be a telephone transmitter 24. The repeating coil 5 has a secondary winding 25, the terminals of which lead to the antenna of a wireless system or to the line of a wire circuit, according to the particular use to which the apparatus is put.

The operation of the system illustrated in Fig. 1 is as follows: The audion 1 is rendered active by the heated filament 7, which emits a stream of negative ions across the space intervening between it and the positively charged plate 2. This stream passes through the interspaces of the grid. The battery 10, acting through the resistance of the coil 11, tends to maintain a steady flow of current in the output circuit, including the ionized space between the plate 2 and the filament 7. The flow of current across the ionized space, however, is not steady but is caused to

fluctuate at a very high frequency, by reason of the interaction between the input and output circuits through the repeating coil 6. The frequency of the sustained oscillations produced by this arrangement may be varied by adjusting the capacities of the various condensers in the circuit. The high frequency currents in the output circuit are transmitted by the repeating coil 5 into the line or antenna to which the secondary winding 25 may be connected.

By means of the telephone transmitter 24, the amplitude of the sustained oscillations is modified or modulated in accordance with sound waves which are of a lower order of frequency. This may be explained as follows: At the normal potential of the battery 16 impressed on the grid 13, the sustained oscillations are produced at a constant amplitude. At a higher potential, due to a positive impulse from the winding 14, the current in the output circuit is increased, and the amplitude of the high frequency oscillations is greater. Conversely, at a lower potential, due to a negative impulse, the oscillations become lesser in amplitude than normal. Thus each pulsation of potential, caused by speaking into the transmitter 24, is effective in producing a corresponding variation in the amplitude of oscillations of current, and therefore of energy in the output circuit and likewise in the line or antenna.

In Fig. 2 is shown an arrangement differing from that of Fig. 1 in that the battery 10 thereof, corresponding to the like numbered battery in Fig. 1, is connected in series with the high impedance coil 11 in bridge of the output circuit. The arrangement is also different in that the battery 16 is included in a bridge of the input circuit in series with an adjustable resistance 26.

In Fig. 3 is illustrated a modified circuit in which the battery 10 is included in series with the high impedance coil 11 as it is in Fig. 2, but primary windings 3 and 4 of the repeating coils 5 and 6 are connected in parallel with relation to each other instead of in series as in Figs. 1 and 2.

In Fig. 4 an arrangement is shown in which two audions 1^a and 1^b are used. Here the battery 10 is connected to a central point in the winding of the high impedance coil 11, the outer terminals of which are connected to the two plates 2^a and 2^b, respectively, of the two audions. Battery 16 is likewise connected to a midpoint of an adjustable resistance 26, the outer terminals of which are connected to the two grids 13^a and 13^b. In the system of Fig. 4, therefore, the battery 10 tends to supply a steady flow of current through both audions from the plates 2^a and 2^b to the two filaments 7^a and 7^b, respectively. The battery 12 supplies current to both of the filaments 7^a and 7^b. The operation is such that the impulses from the repeating coils 6 and 15 produce at any instant of time opposite potential variations on the grids 13^a and 13^b, and these opposite potential variations produce an effect which is cumulative in the output circuit to which the plates 2^a and 2^b are connected.

What is claimed is:

1. The combination with a vacuum tube having a filament, a plate and a grid, an input circuit connected with the grid and an output circuit connected with the plate; of means for impressing sustained high frequency oscillations on said input circuit; and a source of low frequency potential variations connected to said input circuit, said output circuit comprising means for supplying modulated high frequency oscillations.

2. The combination with a vacuum tube having a filament, a plate and a grid, an input circuit connected with the grid and an output circuit connected with the plate; of means for impressing sustained high frequency oscillations on said input circuit, and signaling means associated with said tube, said output circuit comprising means for supplying high frequency oscillations modulated in accordance with the signal.

3. The combination with a generator of high frequency oscillations, comprising a repeater of the feed-back type and an input and an output circuit connected to each other to produce sustained high-frequency oscillations, of means for modulating said high frequency oscillations in accordance with low frequency signaling impulses.

4. The combination with a generator of high frequency oscillations, comprising a vacuum tube repeater of the audion type and input and an output circuit therefor arranged to react upon each other to produce sustained high-frequency oscillations, of means for modulating said high frequency oscillations in accordance with low frequency signaling impulses, and a transmission circuit for receiving the modulated high frequency oscillations.

5. The combination with a generator of high frequency oscillations, comprising a repeater having an input and an output circuit connected with each other for producing sustained high-frequency oscillations, of a source of low frequency potential variations, and circuit connections by which said low frequency potential variations vary the amplitude of said high frequency oscillations.

6. The combination of a vacuum tube repeater of the audion type adapted to generate sustained high frequency oscillations, with means for modulating said oscillations in accordance with a telephone signal to be transmitted, and means for transmitting the modulated high frequency oscillations so produced.

7. In a system for signaling by high frequency oscillations, a thermionic device of the audion type for modulating high frequency oscillations in accordance with low frequency signals, said device having an input and an output circuit, said input circuit comprising a heated filament and a controlling electrode, means for generating low frequency signals, and means for impressing said low frequency signals upon the input circuit of said device.

8. In a system for signaling by high frequency oscillations, a thermionic device for modulating said high frequency oscillations in accordance with low frequency signals, said device comprising an evacuated vessel containing a filament, an auxiliary electrode and a plate element, and means for changing the potential of the auxiliary electrode with respect to the filament in accordance with low frequency signals to be transmitted.

9. In a system for signaling by high frequency oscillations, a thermionic device for modulating said high frequency oscillations in accordance with low frequency signals, said device comprising an evacuated vessel containing a filament, an auxiliary electrode and a plate element, means for generating low frequency signals, and means for impressing said signals between the filament and the auxiliary electrode.

10. In a system for signaling by high frequency oscillations, a thermionic device for modulating said high frequency oscillations in accordance with low frequency signals, said device comprising an evacuated vessel containing a filament, a grid and a plate element, means for generating low frequency signals, and means for simultaneously impressing on said grid the high frequency oscillations and the low frequency signaling impulses.

11. A signaling system comprising an audion having filament, grid and plate electrodes, means for supplying high frequency oscillations to said audion, signaling means associated with said audion, and a circuit connected to said plate and said filament electrodes for leading off from said audion high frequency oscillations modulated in accordance with said signal.

12. A signaling system comprising an audion having filament, grid and plate electrodes, means for supplying high frequency oscillations, means for supplying signaling oscillations, means comprising said audion for modulating said high frequency oscillations in accordance with said signaling oscillations, and a circuit connected to said filament and plate electrodes for leading off the modulated oscillations from said audion.

13. The combination with a generator of high frequency current, comprising a repeater and an input and an output circuit therefor united with each other, said repeater having an electrode located in said input circuit; of a transmission line united with said output circuit, and a source of low frequency potential variations connected to said electrode.

14. The combination with an audion having a filament, a plate and a grid, an input circuit connected with the grid and an output circuit connected with the plate; of an inductive connection between said output and said input circuits adapted to the production by said audion of sustained high frequency oscillations, and a sending device, adapted for producing signaling impulses of low frequencies, connected with said input circuit.

15. The combination with a generator of high frequency current, comprising a repeater, an input and an output circuit therefor and a connection between said circuits; of a transmission line united with said output circuit, and a sending device adapted for producing signaling impulses of low frequencies, connected with said input circuit.

16. The combination with a generator of high frequency current, comprising an evacuated vessel, means for producing a state of ionization in said vessel, and an input and an output circuit interconnected to react upon each other; of means connected with said input circuit for producing low frequency potential variations in said input circuit.

17. The combination with a generator of high frequency current, comprising an evacuated vessel, means for producing a state of ionization in said vessel, and an input and an output circuit inductively connected with each other; of a source of low frequency potential variations connected with said input circuit for controlling the amplitude of the high frequency currents developed by said generator.

18. The combination with a generator of high frequency current, comprising an evacuated vessel, means for producing a state of ionization in said vessel, and an input and an output circuit connected with each other; of means included in said circuits for adjusting the frequency of said current; and a source of low frequency potential variations connected with said input circuit for controlling the amplitude of the high frequency currents developed by said generator.

19. In apparatus of the kind described, the combination of an evacuated vessel and means, including a cathode, for producing a state of ionization in said vessel; of an input anode and an output anode in said vessel; an output circuit connected to said output anode and including an adjustable condenser and a source of continuous cur-

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rent, an input circuit connected to said input anode and inductively connected to said output circuit, and means connected with said input circuit for producing low frequency potential variations in said input circuit.

20. The combination with an audion having an input circuit and an output circuit inductively connected with each other; of means connected with said input circuit for producing low frequency potential variations in said input circuit.

In witness whereof, I hereunto subscribe my name this 12th day of March, 1917.

EDWIN H. COLPITTS.

H. W. NICHOLS.

LOW FREQUENCY SIGNAL REPEATER.

APPLICATION FILED SEPT. 24, 1913.

1,257,381.

Patented Feb. 26, 1918.

2 SHEETS—SHEET 1.

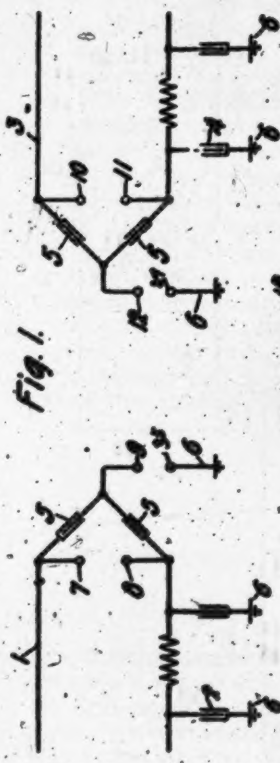

Fig. 1.

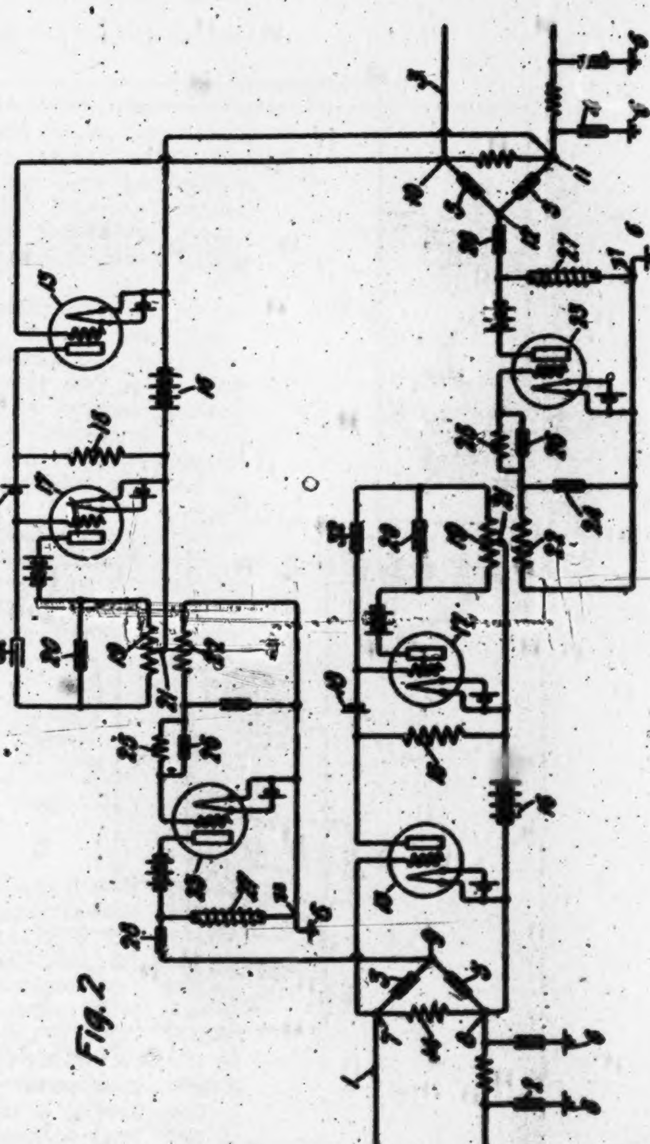

Fig. 2

Witnesses:

O. E. Rasmussen

John Waldheim

Inventor:

Harold W. Nichols.

by S. C. Hunnel. Att'y

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H. W. NICHOLS.

LOW FREQUENCY SIGNAL REPEATER.

APPLICATION FILED SEPT. 24, 1915.

1,257,381. Patented Feb. 26, 1918.

2 SHEETS—SHEET 2.

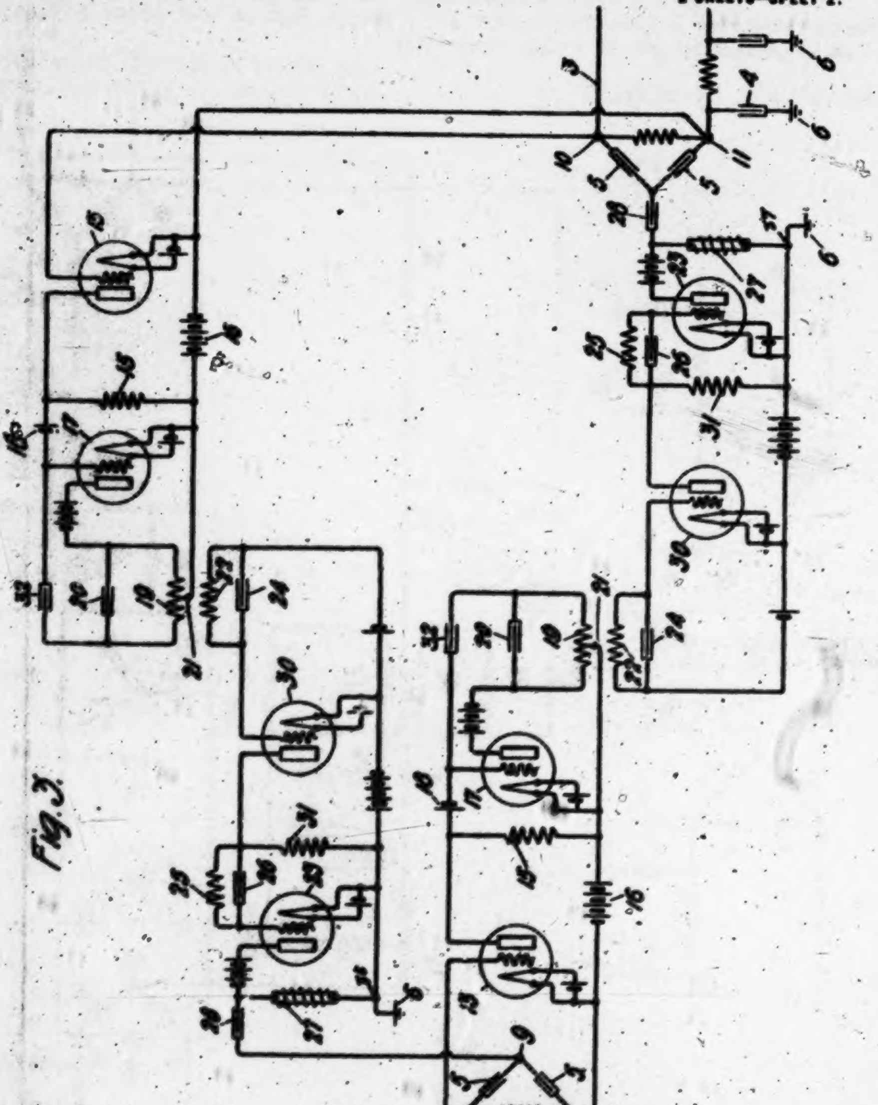

Fig. 3.

Witnesses:

O. E. Rasmussen

John Waldheim

Inventor:

Harold W. Nichols.

by A. C. Dennes. Att'y

UNITED STATES PATENT OFFICE.

HAROLD W. NICHOLS, OF MAPLEWOOD, NEW JERSEY, ASSIGNOR, BY MESNE ASSIGNMENTS, TO WESTERN ELECTRIC COMPANY, INCORPORATED, A CORPORATION OF NEW YORK.

LOW-FREQUENCY-SIGNAL REPEATER.

1,257,381. Specification of Letters Patent. Patented Feb. 26, 1918.

Application filed September 24, 1915. Serial No. 52,508.

To all whom it may concern:

Be it known that I, Harold William Nichols, a citizen of the United States, residing at Maplewood, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Low-Frequency-Signal Repeaters, of which the following is a full, clear, concise, and exact description.

This invention relates to a method of and apparatus for the repeating of messages from one submarine cable or similar line to another. Its object is to amplify and repeat in one line low frequency currents originating in another without destroying the property of duplex operation of either line, and to perform this operation efficiently and with fidelity.

These objects are accomplished by employing auxiliary circuits between the two lines in question, supplying these circuits with alternating current, varying the characteristics of the currents in these circuits by means of the incoming signal, and translating these variations to the forms of signals to be transmitted to the outgoing lines. These operations are desirable for reasons which will appear in the following discussion of the problems involved in the efficient repetition of signals between two duplex cables, telegraph lines or other circuits carrying low frequency signaling currents.

It has been found that repeaters of the mechanical type, for example, those in which an electromagnetic receiving device actuates a microphone, are not suitable for use in connection with low frequency signaling circuits. On the other hand, the thermionic repeater of the audion type, by reason of its high sensitiveness and its freedom from distorting effects, is especially fitted for this kind of work. This repeater consists of an electron-emitting cathode, an anode, and an auxiliary electrode, all inclosed in an evacuated vessel.

An important feature of this device in connection with this problem is that its input circuit and its output circuit necessarily have one point in common, since the repeater has but three terminals. This fact introduces into the problem of repeating from one duplex cable to another some difficulties which are overcome in this invention, and which will be explained in connection with the drawings.

In these drawings, Figure 1 shows the circuit arrangements of two duplex cables terminating at a repeater station; Fig. 2 shows a method of repeating from one of these cables to the other in accordance with this invention; and Fig. 3 shows a modified form of the invention in which greater amplification of signals is secured. In all of these figures, corresponding parts are denoted by like numerals.

Referring to Fig. 1, 1 and 3 are cable conductors and 2 and 4 their balancing artificial cables introduced, as usual, to permit duplex operation in connection with the condensers 5. 6 represents a ground connection.

In receiving a signal over cable 1 the receiving instrument is connected to the receiving terminals 7—8, and in sending through this cable an electromotive force is applied between the transmitting terminals 35—9. When the artificial line is exactly like the corresponding actual line, and when the condensers 5 are equal, this sending electromotive force produces no difference of potential between the terminals 7—8, and, consequently, the receiving instrument is not affected in sending from the station at which it is located. Duplex operation is therefore possible over these two cables, and its success depends upon the accurate simulation of the actual line by its artificial line.

Now, if it is desired to relay signals from cable 1 to cable 3, it will be necessary to connect the receiving terminals 7—8 of cable 1, through an amplifier, with the transmitting terminals 12—37, of cable 3, and similarly terminals 10—11 with terminals 35—9, and, as stated before, it is desirable to use the thermionic amplifier for this purpose. That amplifier, however, has a conducting connection between input and output circuits, and an examination of Fig. 1 will show that no matter how such an amplifier is connected from the receiving terminals of one cable to the transmitting terminals of the other, it will short-circuit one of the lines and destroy the property of duplex operation.

There must be no conducting path, except for the earth, from one cable to the other

if duplex operation is to be maintained. To eliminate such a conducting connection, an inductive one might be substituted, for instance by connecting the receiving terminals of one cable to the primary winding of a transformer, the secondary winding of which might then be connected, through an amplifier, to the transmitting terminals of the other cable.

This is the invention of another and is, moreover, open to the serious objection that the transformation of currents, of the wave forms and frequencies used in telegraphy, is not efficient and that it requires specially designed and expensive transformers. This invention eliminates the necessity for inefficiently transforming currents of the low fundamental frequency and complicated wave form here encountered, and substitutes therefor efficient transformation of sinusoidal currents of a single relatively high frequency in a manner more completely described in connection with Fig. 2 which represents a preferred form of the invention, and also in connection with Fig. 3 in which an additional amplifier is used to secure greater amplification.

Referring to Fig. 2, numerals 35, 37 and 1 to 12 inclusive, represent two duplex cable terminals, as explained in connection with Fig. 1. 13 is a thermionic amplifier of the audion type whose function is to amplify the potential difference over the resistance 14 inserted between the receiving terminals 7—8 of the first cable. Its action is as follows: When a potential difference is established over the input terminals of 13, the effect is to change the current set up by the battery 16 in the output circuit of the amplifier, which includes resistance 15. The change in voltage drop over 15, due to that input potential difference, is much greater than the latter. Another function of the amplifier 13 is to prevent the reaction upon the incoming cable of the current in the apparatus next to be described. This effect is secured because the thermionic amplifier is a unilateral device and permits the transfer of power in but one direction through it.

17 is another amplifier adapted to act as an oscillation generator. Any amplifier, when arranged so that power may be fed back from its output circuit to its input circuit, for example, by inductively connecting these circuits, will oscillate freely if the amplifying power is sufficiently large. The power represented by this free oscillation is drawn from the battery in the output circuit. In the oscillator of the figure a tuned circuit, comprising coil 19 and condenser 20, is included in the output circuit, while the input circuit includes half the coil 19, due to the fact that the filament or cathode of the repeater is connected to coil 19 at the point 21. Since the two halves of the coil 19 are related by mutual inductance, the two circuits are inductively connected and the device acts as an alternating current generator of oscillations whose frequency is determined by the tuned circuit 19—20.

The input circuit of this oscillating amplifier is also connected across resistance 15, by which connection the amplified signal voltage is impressed upon the input circuit of 17, preferably through the battery 18 which is used to maintain the potential of the grid at a suitable value with respect to that of the filament. The effect of impressing this variable signal voltage upon the amplifier 17 is to change its amplifying power and, therefore, to vary the amplitude of the alternating current in its output circuit in accordance with the signal received over the cable 1. This method of modulating the amplitude of an alternating current is not the invention of this applicant and is not claimed in this application.

The coil 19 is inductively coupled to coil 22 of the tuned circuit 22—24, and since now a pure alternating current of relatively high frequency is in question, the transformation by the transformer 19—22 is efficient in contrast to the case in which the signal waves themselves must be transformed.

It is now necessary to rectify this modulated current so that the effect of the high frequency alternating current shall be eliminated. This is done by the thermionic element 23 in whose input circuit are inserted condenser 26 and resistance 25. These assist in the rectification (which takes place in any thermionic element of the audion type when its output terminals are closed through a low impedance) as follows: Suppose that an impulse of positive potential with respect to the filament is impressed upon the grid circuit so that the grid becomes positively charged. This charge will now be rapidly neutralized by the flow of electrons from the heated filament to the grid. If now this positive impulse is followed by a negative impulse, the negative charge remaining upon the grid will be still further increased, and, therefore, the space current in the audion, whose magnitude is governed by the charge upon the grid, will be decreased more than would be the case if the negative charge first mentioned had been free to leak away. It is prevented from so doing by the condenser 26. However, it is not desirable to retain this negative charge upon the grid indefinitely, and to prevent this the resistance 25 is shunted about the condenser. This resistance is so large that the leak of current through it in a time comparable with the period of the high-frequency oscillation is small, but this leakage path is made of sufficiently low resistance to permit the complete discharge of the

nals. The effect of this combination of resistance and capacity is, therefore, to increase the rectifying effect of the thermionic element. As in the operation of any rectifier, it responds only to the envelop of the high frequency oscillations, that is, it produces in its output circuit a direct current upon which is superposed a current of the wave form of the signal received from the first cable. The high inductance choke coil 27 permits the free passage of the necessary direct current in the output circuit of 23 while offering a high impedance to the signal currents superposed upon it, which latter are therefore impressed upon the transmitting terminals 12—37 of the outgoing cable, preferably through condenser 28. A condenser 32 is preferably added in the output circuit of amplifier 17 to prevent the short-circuiting of resistance 15. A similar system of circuits leads in the opposite direction, that is, from the receiving terminals 10—11 to the transmitting terminals 35—9 of the first cable.

Fig. 3 represents an arrangement similar to Fig. 2 except that an additional amplifier is added to still further increase the energy of the repeated signals impressed upon the second line. In this arrangement the tuned circuit 22, 24 instead of being directly connected to the rectifying element 23, is now connected to the input electrodes of the thermionic amplifier 30. The output circuit of this amplifier is completed through the resistance 31 and contains an energizing battery as shown. The rectifying element 23 is then connected across the terminals of resistance 31. This modifies the operation of the device only in so far as it increases the voltage supplied to the rectifier, and consequently increases the value of the rectified current. An advantage secured by the use of this amplifier, in addition to the greater power obtained, is that the thermionic element, when acting as a rectifier, is more efficient when the voltage impressed across its input terminals is large. In all other respects this arrangement is similar to that shown in Fig. 2.

Although this invention has been shown as applied to the amplification of signals from one duplex cable to another, it is obvious that its advantageous use will not be restricted to this type of apparatus. Its use may be desirable in any system requiring the transforming or repeating of low frequency signals.

What is claimed is:

1. In combination with two duplex lines having receiving and transmitting terminals adapted for electrical signaling with low frequency currents, a device for relaying signals from one to the other of said lines, a similar device for relaying signals in the opposite direction, means for providing for non-interference between said devices, each of said devices consisting of a circuit, means for producing therein electrical oscillations capable of efficient transformation, means for varying the character of said oscillations in accordance with a signal received from one of said lines, said varying means comprising a resistance shunted across the receiving terminals of said line, an amplifier having an output circuit, and a transformer whereby the effect of said variable oscillations is communicated to said amplifier and thereby augmented, a detector connected with said output circuit, and means for impressing upon the other of said lines the detected current.

2. In telegraphy, two duplex lines adapted to transmit low frequency signals, each line having separate receiving and transmitting terminals, the combination with the transmitting terminals of one line and the receiving terminals of the second line, of a circuit containing a modulator wherein is developed an alternating current, of a thermionic amplifier interlinked with said circuit and with the receiving terminals of the first of said lines whereby the amplitude of the alternating current is varied in accordance with the electrical signals in said line. of a transformer for inductively communicating the oscillations in said current to a second circuit, of a thermionic detector whose input electrodes are connected to said second circuit, the transmitting terminals of said line being so connected to the output circuit of said detector as to be influenced by the rectified currents appearing in said output circuit.

3. In telegraphy, two duplex lines adapted to transmit low-frequency signals, the combination with the receiving terminals of one of said lines and the transmitting terminals of the second of said lines, of a generator of high frequency oscillations, means for directly coupling said generator to said receiving terminals whereby the high frequency oscillations are varied in accordance with the wave form of the signals received over one of said lines, a detector, and a transformer whereby the effect of said modulated current is communicated to said detector, and means associated with the output circuit of said detector for impressing the detected current upon said transmitting terminals.

4. In telegraphy, two lines adapted to transmit low frequency signals, each line having separate receiving and transmitting terminals, the combination with the transmitting terminals of one line, and the receiving terminals of the second line, of a resistance shunted across said receiving terminals, of an oscillation generator wherein is developed an alternating current, of a thermionic amplifier having an input cir-

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cuit and an output circuit, said resistance serving as a means for impressing the electrical signals in said line upon said input circuit, of means for directly impressing the amplified signals in said output circuit upon said oscillation generator, whereby the amplitude of the alternating current is varied in accordance with said signals, of a thermionic detector having an input circuit and an output circuit, of a transformer for inductively communicating the oscillations in said current to the input circuit of said detector, the transmitting terminals of said line being so connected to the output circuit of said detector as to be influenced by the detected current appearing in said output circuit.

5. In telegraphy, a duplex line, a vacuum tube repeater containing a cathode and an auxiliary electrode, said line terminating in said electrodes and auxiliary apparatus associated with said line and tube for the two-way transmission of signals.

6. In telegraphy, a duplex line, two shunt paths across said line, one of said paths comprising a resistance, the other being a capacity path, a vacuum tube repeater, means for impressing the drop of potential across said resistance upon the input electrodes of said repeater, and means comprising a second repeater connected to an intermediate point of said capacity path for impressing signaling currents upon said line without effectively impressing them upon said first repeater.

7. In telegraphy, a duplex line, two shunt paths across said line, one of said paths comprising a resistance, the other being a capacity path, a vacuum tube repeater having its input electrodes shunted across said resistance, and means comprising a second vacuum tube repeater connected to the midpoint of said capacity path for impressing signaling currents upon said line without impressing them upon said first repeater.

In witness whereof, I hereunto subscribe my name this 23rd day of September, A. D., 1915.

HAROLD W. NICHOLS.

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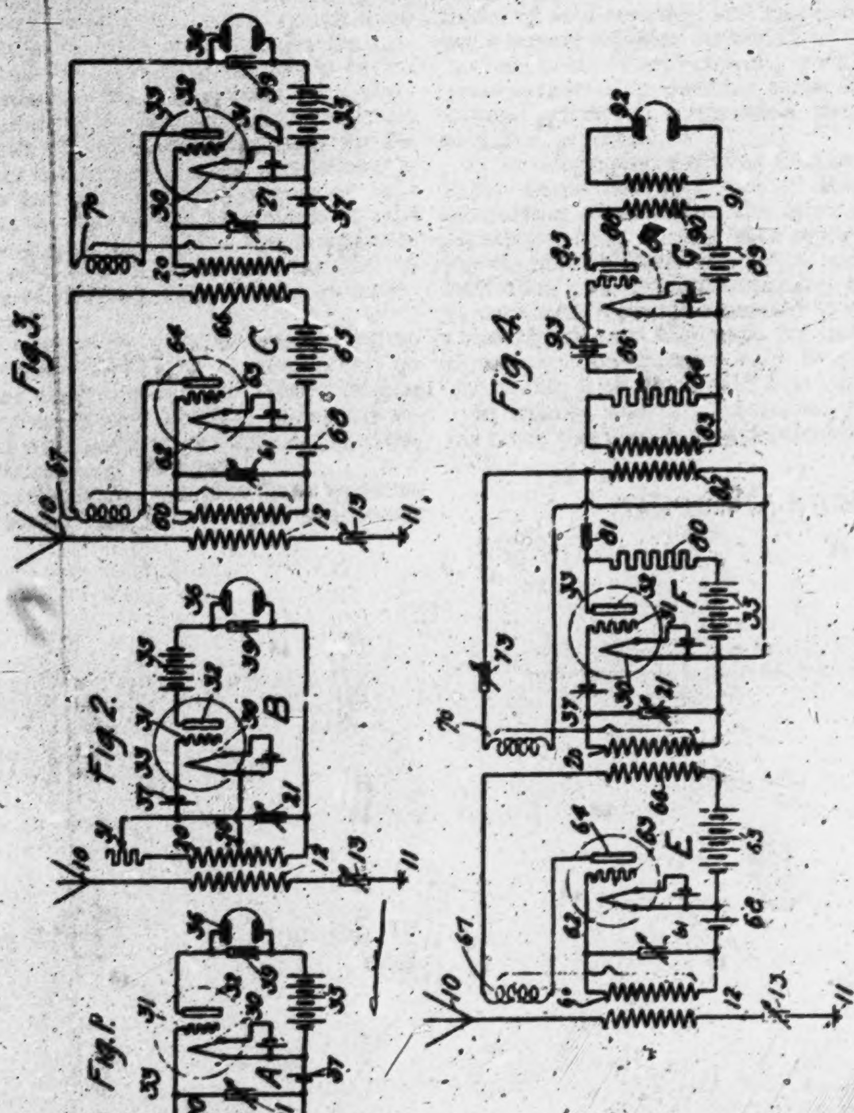
1497

B. W. KENDALL.
HIGH FREQUENCY SIGNALING.
APPLICATION FILED NOV. 29, 1915.

1,330,471. Patented Feb. 10, 1920.



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UNITED STATES PATENT OFFICE.

BURTON W. KENDALL, OF NEW YORK, N. Y., ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

HIGH-FREQUENCY SIGNALING.

1,330,471. Specification of Letters Patent. Patented Feb. 10, 1920.

Application filed November 29, 1915. Serial No. 64,065.

To all whom it may concern:

Be it known that I, BURTON W. KENDALL, a citizen of the United States, residing at New York, in the county of New York and State of New York, have invented certain new and useful Improvements in High-Frequency Signaling, of which the following is a full, clear, concise, and exact description.

This invention relates to a method and apparatus for receiving high frequency oscillations which have been modulated in accordance with low frequency signals, such as speech.

In wireless signaling the extraordinary weakness of the received signals makes it highly desirable to use means for intensifying the effect produced on the translating device. In the case of wireless telegraphy, this is a comparatively simple matter, for the chief requirement is to obtain an indication, with small regard for the distortion produced. In the case of wireless telephony, however, where the high frequency carrier waves are modulated in accordance with the speech signals to be sent, the problem is much more difficult, for the intelligibility of the translated signals depends on the faithful reproduction of the modulations of the carrier waves. This means that the distortion must be kept to a minimum.

The method of intensification which is here shown depends upon the local generation of oscillations at the receiving station, which oscillations are combined with the received oscillations to produce a much stronger effect in the indicator than would be produced by the received oscillations alone.

A method of wireless telegraph reception, which has now become well known in the art, is the heterodyne method, which consists essentially in receiving the weak signal oscillations and combining them with locally generated oscillations of a slightly different frequency. This results in the production of beats which are of a frequency equal to the difference between the frequency of the received and that of the locally generated oscillations. This difference is adjusted to be within the audible limit, and a note corresponding to this beat frequency is heard in the receiver. However, the pitch of this note depends in no way on the form of the transmitted wave but only on the difference in frequency between the transmitted high frequency oscillations and the locally generated oscillations.

While this method is well adapted for telegraphic messages, it cannot, of course, be used for telephonic signaling. It has been found, however, that by generating local oscillations of a frequency identical to the carrier frequency and combining them with the received high frequency oscillations, one can receive oscillations which have been modulated in accordance with speech, and that the resulting translated signals in the receiver are highly intensified. It is obvious that the resulting translated signals in the receiver will also be intensified in case the modulation is not in accordance with speech but in accordance with a musical note, for instance. The invention is of particular advantage in any case where a faithful reproduction of the signal is desired.

The invention will be better understood by reference to the following specification and accompanying drawings, in which Figure 1 shows a receiving station embodying this invention; Fig. 2 shows a modification in which the receiving circuit itself generates the local oscillations; Fig. 3 shows a circuit in which the received oscillations are first amplified and then combined with local oscillations of carrier frequency; and Fig. 4 is a modification of Fig. 3.

Referring to the drawings, in each of the figures 10 represents a receiving antenna of the usual type employed in wireless signaling. This antenna is connected to ground at 11, and between the antenna and the ground connection are placed a suitable variable inductance 12 and condenser 13, by means of which the receiving system may be tuned to any desired frequency, preferably the frequency of the signals which are to be received. This condenser may be shunted by a very high non-inductive resistance or may be omitted entirely.

Inductively associated with the antenna shown in Fig. 1 is a tuned circuit consisting of the inductance 20 and the condenser 21. Connected in shunt to the condenser 21 is a detector, and there is, in this case, shown a detector of the audion type which comprises the usual heated filament 30, a grid 31 and a plate 32, all these being contained in a suitably evacuated vessel 33. The input circuit of this detector comprises the filament 30 and the grid 31, and these are connected in shunt, as mentioned above, to the con-

denser 21. The output circuit includes the filament 30 and the plate 32 and contains in series a suitable source of electrical energy 35, and a telephone receiver 36. In the input circuit of said detector it is desirable to insert a battery 37 in such a manner that a negative pole shall be connected to the grid. A condenser 39 is placed in shunt to the receiver 36 in order to give a low impedance path to such high frequency oscillations as pass through the output circuit.

As thus far described, this system is adapted to receive modulated oscillations and to translate them into audible signals in the receiver 36. The intensity of these signals will, however, be exceedingly low, and the purpose of the invention is to strengthen these signals. It has been found that by superimposing upon the received oscillations locally generated oscillations of identically the same frequency, such strengthening takes place. In this case the local generator 40 is inductively connected to the inductance 20 by means of the inductance 41. A combination of these impressed oscillations with the received oscillations will give a stronger signal in the receiver 36. In fact, it can be shown that, within certain limits, if B is the amplitude of the received modulated wave and A is the constant amplitude of the locally generated oscillations impressed upon the receiving circuit, the intensity of the signals received at 36 will be approximately proportional to the product of A and B.

While in this figure there is shown and described a detector of the audion type, it is to be understood that any other detector, such as a crystal rectifier, may be used although a detector of the form shown is preferred. Also, it is to be understood that while the locally generated oscillations may be set up by an independent generator of any type, such as shown at 40, one may make use of that property of amplifiers and repeaters by virtue of which they may act as generators of oscillations in themselves. Such a circuit is shown in Fig. 2, in which a coupling between the input circuit and the output circuit of this thermionic device is obtained by connecting the filament to some intermediate point 50 of the inductance 20. In this case, as is described in application of Hartley, Serial No. 31,176, filed June 1, 1915, local oscillations will be set up in this receiving circuit, the intensity and frequency of which will be determined by the point of contact 50 and by the period of the circuit as determined by 20 and 21. In this case also, it has been found convenient to insert a variable non-inductive resistance 51, which assists materially in determining the intensity of the locally generated oscillations as shown in application of Heising, Serial No. 51,761, filed September 21, 1915.

Under certain conditions it may be desirable to amplify the received oscillations prior to combining them with the locally generated oscillations. A circuit arranged for this is shown in Fig. 3, in which there is inductively connected to the antenna an amplifying circuit comprising the tuned circuit 60, 61, connected to the input circuit of a thermionic amplifier of the audion type, this input circuit including the usual heated filament 62 and grid 63, and the output circuit including the filament 62 and the plate 64 in series with a power battery 65 and an inductance 66. The usual battery 68 for polarizing the grid may also be used. Inductively connected to the inductance 66 is a detecting circuit, such as circuit D of Fig. 3. This circuit D has a circuit 20, 21 tuned to the carrier frequency and inductively coupled to inductance 66. In shunt to the condenser 21 is a detecting and generating thermionic device 33, similar in every respect to the one described in Fig. 2. The output circuit of this thermionic device 33 contains the power battery 35 and the telephone receiver 36, said receiver being shunted by the condenser 39. In series with this output circuit is also included the inductance 70 which is coupled to the coil 20, thereby arranging for the feed-back of power from the output to the input circuit, causing the circuit as a whole to generate oscillations in a manner similar to that described in connection with Fig. 2. It is to be noted that this coil 70 should be so arranged with respect to 20 that singing or generating shall be produced. While I describe and show this specific circuit D for generating local oscillations, it is to be pointed out that any suitable source of oscillations may be used, and in place of this circuit D, we may use the circuit B of Fig. 2 or the circuit of Fig. 1. In this latter case, it is, of course, obvious that a separate source of oscillations, such as 40, 41 of Fig. 1, will be required.

It is a known fact that, in view of the inherent electrostatic coupling between the input and the output circuits of an amplifier, as brought about by the elements in the vacuum tube, and in view of the electrostatic and electromagnetic coupling unavoidable in the circuit connections, there is a tendency for such an amplifier to sing, and it has been found, in the case of the amplifying circuit C, that it is desirable to prevent such singing, and for this purpose one may supply a feed-back circuit 67 connected in series in the output circuit, the windings of the coil 67 being so arranged as to nullify any tendency to sing. Such operation of an anti-singing circuit is described in the patent of Hartley 1,183,875, patented May 23, 1916, for improvements in electric circuit.

In Fig. 4 there is shown an amplifying

circuit substantially the same as that shown in Fig. 3, which amplifies the received oscillations previously to their combination with the locally generated oscillations. In this Fig. 4, there is a different arrangement of output circuit for the detector. As shown in said figure, there is placed in series with the power battery 35 a high non-inductive resistance 80. Parallel to this output circuit is a circuit containing the relatively large condenser 81 and the primary 82 of a low frequency transformer 82, 83. In shunt to the primary 82 is a circuit containing the inductance 70 and the condenser 73. The coil 70 acts to feed back high frequency power from the output to the input circuit of the vacuum tube. The condenser 73, which is of relatively low capacity, is used to prevent the short circuiting of low frequency oscillations through the coil 70. In this arrangement, the high frequency output of the vacuum tube passes through the circuit 70, 73, and the low frequency oscillations pass through the coil 82 while the direct current passes through the resistance 80.

In series with the coil 83 is the non-inductive resistance 84. In shunt to a part of the resistance 84 is the input circuit of a thermionic amplifier 85 comprising the usual heated filament 86 and grid 87. The output circuit comprises the filament 86 and the plate 38, as well as the power battery 89 and the primary 90 of a transformer 91. This transformer is a telephone repeating coil. The secondary of this repeating coil is connected to the telephone receiver 92 or to any telephone line for further transmission to remote stations. It may be advantageous to place the polarizing battery 93 in the grid circuit of the amplifier to maintain the grid at a proper potential with respect to the filament. In practice, it is desirable that the transformer 82, 83 shall be adapted to work between circuits of high impedance, and that the resistances 80 and 84 shall be large. With the thermionic detectors which I have commonly used, I find that the resistances 80 and 84 may be of the order of one hundred thousand ohms. In this last figure, it will be noted that the circuit E is used solely for amplifying the received high frequency oscillations, while the circuit F is used for combining these amplified oscillations with locally generated oscillations of the carrier frequency, and that the combination gives low frequency oscillations varying in accordance with the signal which was transmitted, and that these rectified or translated signals of audio-frequency are then amplified in the circuit G previously to being received in the telephone receiver 92. It will be noted that the feed-back coil 67 is so connected with respect to the coil 60 as to prevent singing in the same manner as described for this coil 67 in Fig. 3.

While this invention has been described in connection with a wireless telephone system, it will be obvious to one skilled in the art that the invention is not limited in all respects to such systems, but that in certain aspects it is equally well adapted to wire systems in which modulated high frequency signals are sent out from one station and received at another.

What is claimed is:

1. The method of wireless telephony which consists in radiating high frequency carrier oscillations modulated in accordance with speech, in receiving said oscillations, in generating local oscillations of said carrier frequency and combining them with the received oscillations.

2. The method of wireless telephony which consists in radiating modulated high frequency oscillations, in receiving said oscillations and combining them with locally generated high frequency oscillations of the same frequency as the received oscillations and of constant amplitude.

3. The method of high frequency signaling which consists in transmitting high frequency carrier waves modulated in accordance with speech, receiving said modulated high frequency waves, generating at the receiver oscillations of the carrier frequency, combining said locally generated oscillations with the received oscillations, impressing said combination on a detecting device, and translating the resultant combination into audible signals in accordance with the transmitted signals.

4. The method of signaling, which consists in transmitting modulated carrier oscillations, in receiving said oscillations, amplifying said oscillations, generating oscillations of the carrier frequency at the receiving station, and in combining the amplified and locally generated oscillations to reproduce the signal.

5. In a high frequency telephone receiving system, a receiving conductor adapted to receive high frequency carrier oscillations modulated in accordance with speech, a generator of oscillations of the carrier frequency, a detector, means to impress the received oscillations and the locally generated oscillations upon the input circuit of the detector, and a translating device associated with the output circuit of the detector.

6. In a high frequency telephone receiving system, a receiving conductor adapted to receive high frequency carrier oscillations modulated in accordance with speech, a generator of oscillations of the carrier frequency, a detector, a circuit to impress the received oscillations and the locally generated oscillations upon the input circuit of the detector, and a translating device associated with the output circuit of the detector.

7. In a high frequency telephone receiving system, a receiving conductor adapted to receive high frequency carrier oscillations modulated in accordance with speech, a generator of oscillations of the carrier frequency, a detector, a circuit tuned to carrier frequency to impress the received oscillations and the locally generated oscillations upon the input circuit of the detector, and a telephone receiver associated with the output circuit of the detector.

8. A high frequency telephone receiving system comprising an antenna adapted to receive high frequency carrier waves modulated in accordance with speech, a detector, a tuned circuit connected to said antenna and to the input circuit of said detector, a generator of oscillations of the carrier frequency, means for impressing said locally generated oscillations upon said input circuit simultaneously with the reception of the speech modulated oscillations.

9. A high frequency telephone receiving system comprising an antenna adapted to receive high frequency carrier waves modulated in accordance with speech, a thermionic detector of the audion type, a tuned circuit inductively connected to said antenna and connected to the input circuit of said detector, a generator of oscillations of the carrier frequency, means for impressing said locally generated oscillations upon the input circuit of said detector simultaneously with the reception of speech modulated oscillations.

10. A wireless telephone receiving system comprising an antenna adapted to receive high frequency carrier waves modulated in accordance with speech, a thermionic detector of the audion type, a local generator of oscillations of the carrier frequency, means for impressing upon the input circuit of said detector the locally generated oscillations and the received high frequency oscillations modulated in accordance with speech, and a telephone receiver associated with the output circuit of said detector.

11. In a wireless telephone receiver system, a thermionic device of the audion type, means for impressing upon the input circuit of said thermionic device received high frequency carrier oscillations modulated in accordance with speech, means for causing said thermionic device to generate oscillations of the carrier frequency and for impressing said locally generated oscillations upon the input circuit of said thermionic device simultaneously with the receipt of the modulated high frequency oscillations, and a telephone receiver associated with the output circuit of said thermionic device.

12. A system for detecting modulated carrier oscillations, said system comprising an electric discharge device having an anode, a cathode, and an impedance-controlling element, an input circuit and an output circuit, means for causing said output circuit to react upon said input circuit to set up oscillations, and means causing the frequency of the oscillations thus set up to be the same as that of the modulated carrier oscillations.

13. A signal receiving system comprising an electric discharge device having a cathode, an anode, an impedance-varying element, an input circuit and an output circuit, means for impressing upon said input circuit carrier oscillations modulated in accordance with variable low frequency waves, means for causing said discharge device to generate oscillations of the carrier frequency and for impressing said locally generated oscillations upon said discharge device simultaneously with said modulated oscillations, and signal-reproducing means associated with said output circuit.

14. A receiving system comprising a detector, means for impressing upon the input circuit of said detector carrier oscillations modulated in accordance with a relatively low frequency wave, a local generator of oscillations of the carrier frequency, means for impressing upon said detector the locally-generated oscillations and the modulated oscillations, and a translating device associated with the output circuit of said detector for receiving and utilizing the detected oscillations.

15. A receiving system comprising means for amplifying weak oscillations, means for impressing the received oscillations modulated in accordance with a low frequency wave upon said amplifying means, a local generator of oscillations of the frequency of said modulated oscillations, translating means for obtaining low frequency waves from oscillations modulated in accordance with waves of said low frequency, and means for impressing said received modulated oscillations and said locally-generated oscillations simultaneously upon said translating means.

16. A telephone receiving system comprising means for amplifying weak oscillations, means for impressing received oscillations modulated in accordance with speech upon said amplifying means, a local generator of oscillations of the frequency of said received oscillations, translating means for obtaining low frequency waves from oscillations modulated in accordance with waves of said low frequency, and means for impressing said received oscillations and said locally-generated oscillations simultaneously upon said translating means.

In witness whereof, I hereunto subscribe my name this 26th day of November A. D., 1915.

BURTON W. KENDALL.

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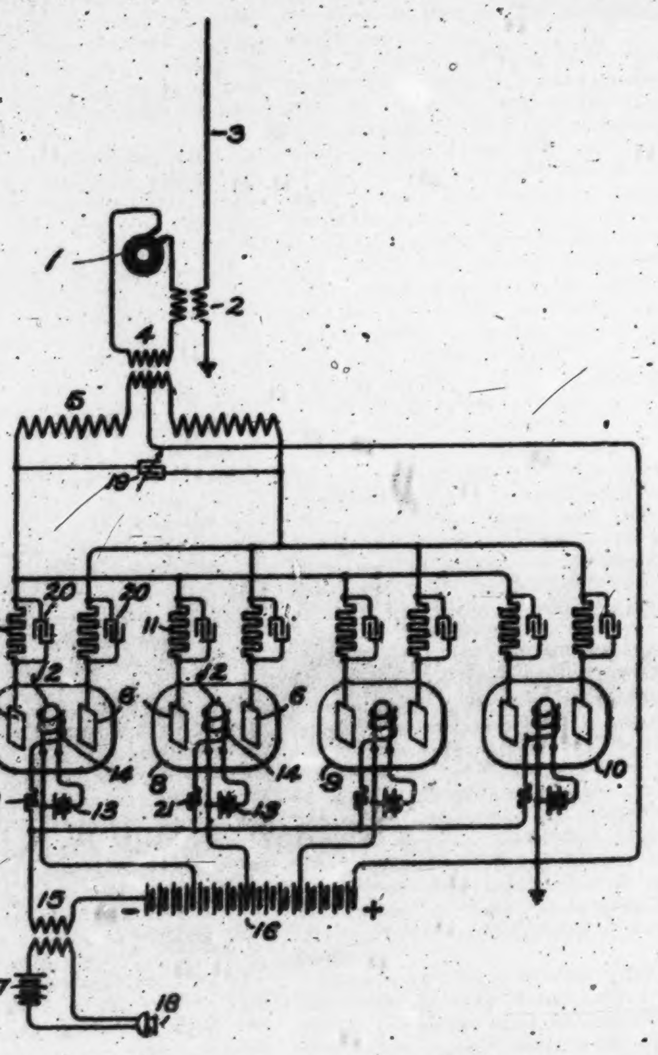
E. F. W. ALEXANDERSON.

METHOD OF AND MEANS FOR CONTROLLING ELECTRICAL ENERGY.

APPLICATION FILED JUNE 15, 1914. RENEWED SEPT. 24, 1919.

1,340,101. Patented May 11, 1920.



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UNITED STATES PATENT OFFICE.

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METHOD OF AND MEANS FOR CONTROLLING ELECTRICAL ENERGY.

1,340,101. Specification of Letters Patent. **Patented May 11, 1920.**

Application filed June 15, 1914, Serial No. 845,115. Renewed September 24, 1919. Serial No. 325,969.

To all whom it may concern:

Be it known that I, ERNST F. W. ALEXANDERSON, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Methods of and Means for Controlling Electrical Energy, of which the following is a specification.

My present invention relates to a method of and means for controlling electrical energy and more particularly to the control of energy used for transmitting signals through space. While in the description which follows I have illustrated its utility when applied to wireless telephony, it is capable of use for other purposes as well.

In a copending application, Serial No. 835,423, filed April 30, 1914, I have described and claimed a system of wireless signaling in which a comparatively large amount of energy may be controlled by means of the feeble current set up in an ordinary telephone transmitter. In this case the amount of energy transmitted to the antenna from a local source of high frequency current is varied by means of a relay or electron discharge device which is controlled by the current from a telephone transmitter in such a way as to vary its conductivity. With this arrangement, in order to produce the desired variation in the antenna current, it is necessary that a considerable amount of the total energy of the local source shall be absorbed in the relay circuit. In all of the modifications shown in my prior application the greater part of the energy is absorbed in the relay itself. Hence the amount of energy which may be effectively communicated to the antenna is limited by the absorptive capacity of the relay used. At the present time this capacity is limited by difficulties which appear to be inherent in the manufacture of apparatus of this type.

The energy which may be controlled in such a system might be increased by connecting several relays in parallel, in which case the amount which could be controlled would vary directly as the number of relays used. By connecting the relays in parallel with resistance in series therewith according to my invention however the amount of energy which can be controlled will vary substantially as the square of the number of relays used.

My invention will best be understood by reference to the following description taken in connection with the accompanying drawing in which I have shown diagrammatically a system of connections whereby the desired result may be accomplished. As here indicated a source of high frequency energy 1 is connected through the usual transformer 2 with the antenna 3. The primary 4 of an oscillation transformer is also connected in series with the source 1 and the primary of transformer 2. The terminals of the secondary 5 of the oscillation transformer are connected to the anodes 6 of a series of electron discharge devices or relays 7, 8, 9, 10 through resistances 11 as shown. These relays also comprise filamentary cathodes 12 with local sources of current 13 for heating the same. The cathodes are surrounded by grid-shaped conducting bodies 14. The grids are all connected to one terminal of the secondary of transformer 15, to the other terminal of which is connected a battery 16 and the cathodes are connected to various points in the battery. One end of the battery is preferably grounded as shown. The primary circuit of transformer 15 includes a source of direct current 17 and a telephone transmitter 18. The cathodes are also connected to the middle point of the secondary 5 of the oscillation transformer. An adjustable condenser 19 is preferably connected across the terminals of the secondary of the oscillation transformer 5, although in some cases the capacity of the relays may be great enough so that this will not be required.

With the arrangement here shown it will be seen that the current in the antenna will vary in accordance with the current through the primary 4 of the oscillation transformer. The amplitude of the current in the primary 4 will in turn depend upon the current flowing in the secondary circuit. It will be apparent that a certain proportion of the energy from the source 1 will be diverted to the secondary circuit and absorbed in the resistances and the relay devices therein. The system may be so designed and adjusted that the energy thus absorbed will in general bear a certain ratio to the total amount of energy derived from the source 1.

hence by varying the amount of energy absorbed in the secondary circuit the amplitude of the antenna current will be varied in substantially the same proportion.

The relays used may assume a great variety of forms. In the form of relay indicated in the present case there will normally be a flow of negative electricity from the cathode to the anodes but no flow of current in the opposite direction. The amplitude of the current flow through the relay may be varied by varying the potential impressed upon the grids 14. If a large enough negative potential is impressed thereon the flow of current may be stopped altogether. If a positive potential is impressed upon the grids the current flow will be increased. For convenience of description let it be assumed that the potential of the grid 14 is such that little or no current will flow through the relay 7 when the high frequency potential of the secondary 5 of the oscillation transformer is applied to the electrodes. The negative potential of the grids of the relays 8, 9 and 10 with respect to their cathodes will be progressively greater. If now a current wave is produced in the transformer 15 of such a direction as to overcome the negative potential of the grids 14, current will begin to flow first through the relay 7 and will gradually increase to a maximum value. If the potential of the current wave is great enough it will gradually overcome the negative potential of all of the grids and current will begin to flow successively in relays 8, 9 and 10. It will of course be understood that when the voltage impressed upon the grids from the transformer 15 begins to decrease the reverse action will take place, that is, current will cease to flow first in relay 10, next in relay 9 and so on until the impressed potential falls to zero and no current will flow as in the beginning. The relays may be so designed and the potentials applied thereto so chosen that when the current in relay 7 reaches its maximum, current will begin to flow in relay 8 and when the current in relay 8 reaches its maximum, current will begin to flow in relay 9 and so on.

Relay devices of the general type shown herein vary somewhat in their characteristics and in some cases the proportionality between the current flow and the voltage impressed upon the grid is constant only over a somewhat limited range. In such cases it may be desirable to so choose the potentials applied to the grids that before the current in one relay has reached its maximum, current will begin to build up in the next relay and so on. In this way the system may be so designed that the current flow therein will be substantially proportional to the voltage variation in the transformer 15 throughout the entire range.

When current first begins to flow in the relay circuit the greater part of the drop in potential will occur in the relay itself and hence the relay will be called upon to absorb most of the energy of the secondary circuit. As the current increases however the drop through the resistance 11 will increase and the proportionate amount of energy absorbed by the relay will decrease. The maximum energy which the relay will be required to absorb will be when the current has reached one-half of its maximum value and the relay is consuming one-half of the voltage. When the current reaches its maximum value in the relay the amount of energy which the relay will be required to absorb will be practically negligible, the principal drop being in the resistance.

Suppose, for example, that it is desired to control in the secondary circuit a maximum of 10 kilowatts of energy which may be represented by .5 ampere at 20,000 volts. If we do this with a single relay and secure a gradual regulation of the energy from no load to full load, the relay will be called on to consume a maximum of .25 ampere at 10,000 volts or 2.5 kilowatts. It will also be required to absorb energy during the entire period during which the change from minimum to a maximum takes place.

Suppose now it is desired to control a maximum of 160 kilowatts of energy which is represented by 8 amperes at 20,000 volts. If we use four relays as indicated in the drawing each relay will be called upon to take 2 amperes. The maximum amount of energy which any one relay will be called upon to absorb will be 1 ampere at 10,000 volts or 10 kilowatts. The change from minimum to maximum in each relay however will occur in one-quarter of the time required in the case where a single relay was used. Hence the average amount of energy absorbed will be only one-quarter of 10 or 2.5 kilowatts. Thus it will be seen that four relays of the same capacity will be able to control 16 times as much energy as the single relay.

In the type of relay here shown there is an appreciable capacity between the anodes. This results in considerable current flowing through the relay between the anodes when the system is not being used for transmitting signals. As a result a large amount of energy is needlessly wasted in the resistances 11. In order to avoid this it may be desirable to shunt each of these resistances by a condenser 20. This will cut down the high frequency alternating current but will not interfere with the unidirectional flow of current through the relay between the cathode and anodes. It will of course be understood that the resistance 11 may equally well be inserted in series with the cathode instead of in series with the anodes.

In order to prevent the grids 14 from consuming an unnecessary amount of current when they become highly positive, resistances 21 may be inserted in series therewith.

While in the preceding description I have described the application of my system with high vacuum relays which are especially adapted for use with high voltages and low currents, my invention is by no means limited to use with this type of relay. It is equally applicable with relays adapted for lower voltages and larger currents and in which there are appreciable amounts of gas or vapor present.

What I claim as new and desire to secure by Letters Patent of the United States, is,—

1. The method of varying the amplitude of the current flow in a circuit comprising a plurality of parallel paths, each of which contains a relay device, which consists in gradually varying the conductivity of each one of the paths in succession by varying the electrical field of the relay device therein.

2. The method of varying the amplitude of the current flow in a circuit comprising a plurality of parallel paths each of which contains a resistance and a relay device, which consists in gradually varying the conductivity of each one of the paths in succession by varying the electrical field of the relay device therein.

3. The method of varying the amplitude of the current flow in a circuit which comprises a plurality of parallel paths each of which contains a relay device, which consists in gradually varying the conductivity of each one of the relay devices in succession.

4. The method of transmitting signals by varying the amplitude of the current flow in a circuit which comprises a plurality of parallel paths, which consists in gradually varying the conductivity of each one of the paths in succession between minimum and maximum values and maintaining the maximum value in at least one of the paths while varying the conductivity of the others.

5. The method of varying, in accordance with signals to be transmitted, the amplitude of current flow in an antenna having a source of energy connected thereto, which consists in diverting a certain proportion of the energy from said source through a circuit containing a plurality of parallel paths and gradually varying the conductivity of each one of said paths in succession in accordance with the signals to be transmitted.

6. The method of varying the amplitude of current flow in an antenna having a source of energy connected thereto, which consists in diverting a certain proportion of energy from said source through a circuit containing a plurality of parallel paths and gradually varying the conductivity of each one of said paths in succession.

7. The method of varying the flow of current in a circuit connected to a source of energy and having a series of relay devices connected thereto in parallel, which consists in so varying the electrical field in the relay devices that the current flow therein will vary successively in the relay devices from a minimum to a maximum.

8. The combination in a wireless signaling system of a source of high frequency electrical energy, an oscillation transformer in series therewith, a plurality of relay devices connected in parallel to the secondary of said transformer and means for varying the electrical field in said relay devices to successively vary the current flow therethrough from a minimum to a maximum.

9. The combination in a wireless signaling system of an antenna, a source of energy connected thereto, a secondary circuit comprising a plurality of parallel paths for diverting a certain proportion of the energy from said source, a relay device in each of said parallel paths and means for varying the conductivity of each of said paths in succession.

10. The combination in a wireless signaling system of an antenna, a source of energy connected thereto, a secondary circuit comprising a plurality of parallel paths for diverting a certain proportion of the energy from said source, a relay device in each of said parallel paths, and means for successively varying the electrical field in each of said relay devices in accordance with the signals to be transmitted.

11. The combination in a wireless signaling system of an antenna, a source of energy connected thereto, a secondary circuit comprising a plurality of parallel paths for diverting a certain proportion of the energy from said source, and means for varying the conductivity of each of said paths in succession in accordance with the signals to be transmitted.

12. The combination in a wireless signaling system of an antenna, a source of energy connected thereto, a secondary circuit comprising a plurality of parallel paths for diverting a certain proportion of energy from said source, a relay device comprising a plurality of electrodes in each of said parallel paths, a conducting body interposed between the electrodes in each of said relay devices, means for normally impressing a different potential upon each of said conducting bodies, and means for varying the potential impressed upon said conducting bodies.

13. The combination in a wireless signaling system of an antenna, a source of high frequency electrical energy connected thereto, a secondary circuit comprising a plurality of parallel paths for diverting a certain proportion of the energy from said source, a relay device comprising a plurality of

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electrodes in each of said parallel paths, a conducting body interposed between the electrodes of each of said relay devices, and means for successively varying the potential of said conducting bodies in such a way as to successively vary the current flow through said relay devices from a minimum to a maximum.

14. The combination in an electrical distribution system of a source of high frequency alternating current, a circuit connected thereto comprising a plurality of parallel paths each of which contains a relay device, and means for gradually varying the conductivity of each one of the relay devices in succession.

15. The combination in an electrical distribution system of a source of high frequency alternating current, a circuit connected thereto comprising a plurality of parallel paths each of which contains an electron discharge device, and means for varying the conductivity of each one of said electron discharge devices in succession.

16. The combination in a high frequency signaling system of a signaling circuit, a source of high frequency energy connected thereto, a secondary circuit for diverting a portion of the energy from said source, a relay device in said circuit for varying the amount of energy diverted and a resistance in series with said relay device for absorbing a portion of the energy diverted.

17. The combination in a high frequency signaling system of a signaling circuit, a source of high frequency energy connected thereto, a secondary circuit for diverting a portion of the energy from said source, a relay device comprising a plurality of electrodes interposed in said secondary circuit, a conducting body interposed between the electrodes of said relay, means for impressing a variable potential upon said conducting body to vary the amount of energy diverted from said source and a resistance in series with said relay device for absorbing a portion of the energy diverted.

18. The combination in an electrical distribution system of a source of high frequency alternating current, a circuit connected thereto for diverting a variable amount of energy from said source, an electron discharge device in said circuit, means for varying the conductivity of said electron discharge device to vary the amount of energy diverted and a resistance in series with said electron discharge device for absorbing a portion of the energy diverted.

19. The combination in an electrical distribution system of a source of high frequency alternating current, a circuit connected thereto comprising a plurality of parallel paths each of which contains an electron discharge device, means for varying the conductivity of each one of said electron discharge devices in succession and resistances in series with said electron discharge devices for absorbing a portion of the energy in the circuit.

20. Means for controlling the flow of high frequency alternating current in a circuit comprising a plurality of parallel paths comprising a relay device having a cathode and an anode in each of said paths, a current controlling member interposed between said cathode and anode in each of said devices, for gradually varying the current flow therethrough, means for impressing a variable potential upon said controlling members and resistances in series with said relay devices for absorbing a portion of the energy in the circuit.

In witness whereof I have hereunto set my hand this 12th day of June, 1914.

ERNST F. W. ALEXANDERSON.

Witnesses:

BENJAMIN B. HULL,
HELEN ORFORD.

cion in Letters Patent No. 1,340,101.

It is hereby certified that in Letters Patent No. 1,340,101, granted May 11, 1920, upon the application of Ernst F. W. Alexanderson, of Schenectady, New York, for an improvement in "Methods of and Means for Controlling Electrical Energy," an error appears in the printed specification requiring correction as follows: Page 3, line 49, claim 5, for the word "fow" read *flow;* and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 6th day of July, A. D., 1920.

[SEAL.]

M. H. COULSTON,
Acting Commissioner of Patents.

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PAGE

1507

H. J. VAN DER BIJL.
HIGH FREQUENCY SIGNALING.
APPLICATION FILED AUG. 21, 1913.

1,350,752. Patented Aug. 24, 1920.

Fig. 1.

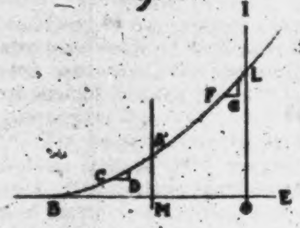


Fig. 2.

Fig. 3.

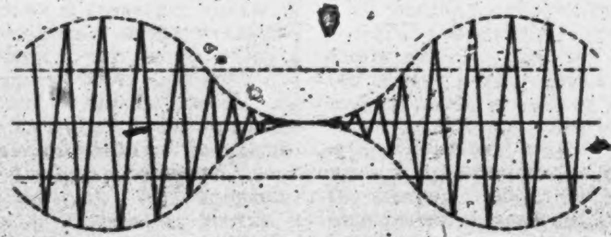
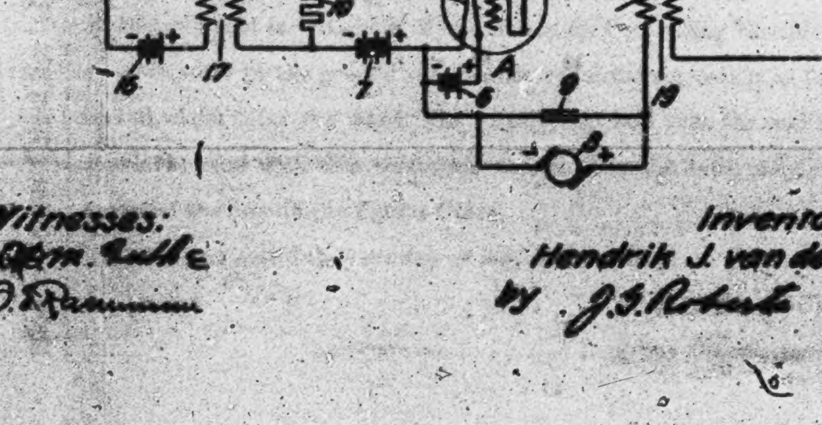


Fig. 4



Witnesses:
[illegible]
[illegible]

Inventor:
Hendrik J. van der Bijl.
by J. S. Roberts
Atty.

UNITED STATES PATENT OFFICE.

HENDRIK JOHANNES VAN DER BIJL, OF NEW YORK, N. Y., ASSIGNOR, BY MESNE ASSIGNMENTS, TO WESTERN ELECTRIC COMPANY, INCORPORATED, A CORPORATION OF NEW YORK.

HIGH-FREQUENCY SIGNALING.

1,350,752. Specification of Letters Patent. Patented Aug. 24, 1920.

Application filed August 21, 1915. Serial No. 46,[illegible].

To all whom it may concern:

Be it known that I, HENDRIK JOHANNES VAN DER BIJL, a subject of the King of Great Britain, residing at New York, in the county of New York and State of New York, have invented certain new and useful Improvements in High-Frequency Signaling, of which the following is a full, clear, concise, and exact description.

This invention relates to signaling by high frequency electrical oscillations or waves along wires or through space, and more particularly it relates to a system for modulating high frequency oscillations in accordance with the frequency and amplitude variations of message waves to be transmitted, and its object is to effect this modulation without destroying the quality characteristics of the message wave.

The invention provides for modulating feeble high frequency oscillations by impressing the currents of telephonic frequencies, together with the high frequency oscillations, on the input circuit of a thermionic amplifier; and makes use of the fact that the amplification of a thermionic amplifier of the audion type depends upon the voltage impressed upon the grid or input circuit. If the amplifying power of the tube for the high frequency oscillations is caused to vary in accordance with the variations of the electromotive force of the telephonic waves of low frequency, the desired modulation is obtained, for there will be produced a high frequency wave the envelop of which is an accurate reproduction of the telephonic wave, and this wave may then be further amplified to any required degree for effective radiation from an antenna.

This will be better understood by reference to the accompanying drawing, in which Figure 1 shows the characteristic curve of a thermionic amplifier of the audion type; Fig. 2 illustrates the form of current curve in the output circuit; Fig. 3 illustrates the current curve in the radiating system; and Fig. 4 shows an arrangement of apparatus to obtain the desired results.

Perfect modulation refers to such a variation in the amplitude of the envelop of the high frequency wave that this envelop is an accurate picture of the low frequency modulating wave.

According to the present invention, the maximum negative value of the low frequency input wave is made just sufficient to reduce the modulated high frequency oscillations to zero amplitude. In other words, the picture of the low frequency oscillations, as shown in the envelop of the high frequency oscillations, just comes down to the zero line, having none of the picture cut off by this zero line.

The process of modulation will be made more evident by a consideration of the characteristic curve shown in Fig. 1, which gives the relation between the output current and the input voltage of the type of amplifier used. In this curve the abscissæ represent the input voltage and the ordinates represent the output current.

If we consider the effect at two different points, C and F, of adding equal positive voltages, CD and FG, on the grid, it is clear that the increase in space current by these equal increments in grid voltage is considerably greater at F than it is at C. The amplification will then be greater at F than at C. Now suppose that the line CD, or the equal line FG, represents a small increment of the high frequency voltage, while the space current, due to the battery in the output circuit, is varied by the low frequency voltage impressed on the grid from point C to point F. It is evident, then, that the amplification of the high frequency will be increased as the potential at which the grid is maintained by the low frequency is increased from point C toward the point F of the figure.

If we suppose the normal grid voltage, when neither high frequency nor low frequency input is applied, to be such that the space current is given by AB, then when the low frequency is applied, assuming it to have equal positive and negative values, the line [illegible] space current will [illegible] equal [illegible] of AB [illegible] will depend upon the shape of the characteristic at which the amplifier is working; that is, upon the form of the low frequency voltage curve, and will in fact be proportional to the slope of the characteristic at the point in question.

If now, high frequency oscillations are

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also impressed upon the grid circuit, the high frequency current in the output circuit will depend in magnitude upon the amount of amplification, that is, upon the part of the characteristic at which the amplifier is working and therefore upon the form of the low frequency voltage curve.

Theoretically, for perfect modulation the low frequency should be large compared with the high frequency input to the modulator, in order that the amplifying power shall not change appreciably due to the high frequency oscillations, but shall be subject to the low frequency voltage only. From a theoretical standpoint the best value for the ratio is infinity, but of course this is not practical, and it has been found that a sufficiently good modulation can be secured if the low frequency voltage input is from three to ten times as large as the high frequency voltage input.

Perfect modulation further requires that the characteristic curve be parabolic, in which case the space current will be proportional to the square of the input voltage, as measured from B. Under these conditions the slope of the curve, which is a measure of the amplifying power, increases linearly from the point B to the point L. Under these conditions, the current in the output circuit of the modulator will have the form shown in Fig. 2 when a sinusoidal low frequency is impressed.

When the low frequency has been dropped out as the energy is passed along through an oscillation transformer, which transmits efficiently only the high frequency output of the modulator, there will remain a high frequency current of the form shown in Fig. 3, the dotted line showing the axis of the sinusoidal envelop of the high frequency oscillations.

In view of the above it has been found desirable to generate high frequency carrier waves of a power commensurate with, or at least not greater than, that of the low frequency signaling waves to be transmitted. Where the signal waves are of low intensity, as is the case where a commercial transmitter is their source, it follows that the generated oscillations should be of an equally low or lower intensity in order that they may be effectively modulated by the telephone currents.

The arrangement of apparatus which I have found useful for the desired purpose will be clearly understood by reference to Fig. 4, in which A is a thermionic amplifier comprising an evacuated vessel 2 which incloses the cathode 3, anode 4 and an auxiliary electrode 5. Cathode 3 is heated to incandescence by the battery 6 and is maintained positive with respect to electrode 5 by means of battery 7. The normal potential of the grid is therefore at some such point as M in Fig. 3, such that the most negative grid potential resulting from the low frequency modulating wave will be just sufficient to carry the space current to zero as at point B. The space current flowing between cathode 3 and anode 4 may be supplied from a direct current generator 8 having in shunt with it a condenser 9 sufficiently high in capacity to afford a path of low impedance for both the low and high frequency currents. The input circuit of the amplifier A includes the cathode 3, battery 7, potentiometer 10, secondary 11 of the oscillation transformer 12 and the electrode 5. The primary 13 of transformer 12 is connected to a high frequency generator 14, which may be of any suitable type, such, for example, as that described in an application of Hartley, Serial No. 31,476, filed June 1, 1915. A telephone transmitter 15 is connected in series with a battery 16 in the primary circuit of a transformer 17, whose secondary is connected to the potentiometer 10 in the input circuit of the amplifier. The output circuit of the amplifier includes the anode 4, winding 18 of the oscillation transformer 19, the condenser 9 and generator 8 in parallel, and the cathode 3.

In the absence of any telephonic impulses, the arrangement described serves simply to produce in this output circuit high frequency currents having substantially the same wave form as that produced by the generator 14, but of greater amplitude.

When, however, telephonic electromotive forces are impressed on the input circuit by means of the transformer 17, the electrode 5 will be made more or less negative with respect to the cathode 3, as the telephonic wave fluctuates from a negative to a positive value. This variation in the potential of the electrode 5 has the effect of varying the amplifying power of the amplifier in accordance with variations in the telephonic electromotive forces. Since the amplification produced by the tube depends upon the relative values of the internal resistance of the tube and the external impedance into which it works, it may be considered that the variation in the potential of the electrode 5 has the effect of varying the impedance of the electron discharge path between cathode 3 and anode 4, and as this path is included in the output circuit of the amplifier, it follows that the impedance of the output circuit is varied in accordance with variations in the telephonic electromotive forces. Thus there will be produced in the winding 18 of the transformer 19 a high frequency current whose amplitude varies with the variation in amplitude of the impressed telephonic electromotive force, that is, the envelop of the high frequency wave will be an accurate reproduction of the telephonic wave.

Since it is desirable that the power value of the impressed telephonic wave shall be greater than that of the generated high frequency oscillations, it will appear that the power value of the modulated high frequency waves produced in the transformer 19 may well be insufficient for effective radiation from an antenna. In such case the power may be amplified to the degree required for radiation by means of some such arrangement as that described in patent to Arnold No. 1,129,942, March 2, 1915. On the other hand, it may well be that the high frequency oscillations have a fairly large power to start with, and in this case it may be necessary to amplify the telephonic power before impressing the two upon a common amplifier.

It has been found desirable to have the external impedance of the output circuit fairly small in order that the characteristic curve of the amplifier shall not be materially altered as the current in the output circuit changes.

While in the present instance the transformer 17 is shown directly connected to a telephone transmitter 15, it is to be understood that this transformer may be connected to a telephone line and serve as a means for relaying, to a wireless antenna or other high frequency signaling system, telephonic or other messages received over long distance conductors. It is also evident that the arrangement shown is suitable for telegraphic transmission by simply substituting a telegraph key for the transmitter 15 and adding an interrupter of any desired frequency. It is evident also that although this invention is particularly well adapted for use in signaling systems, which constitutes the principal application for modulated currents, in its broader aspects the invention may be used wherever it is desired to modulate waves or periodic disturbances, regardless of the use which is to be made of the modulated current or the medium in which the disturbances are produced.

What is claimed is:

1. The method of modulating carrier waves which consists in generating carrier waves of substantially constant amplitude, and invariably amplifying the amplitude of said carrier waves in accordance with a signal.

2. The method of modulating carrier current which comprises generating a high frequency carrier wave of substantially constant amplitude, simultaneously generating a low frequency wave and variably amplifying the high frequency wave in accordance with said low frequency wave.

3. The method of modulation which comprises generating a current of high frequency, generating a current of relatively low frequency, impressing energy from each of these currents in series upon a circuit, generating space current and causing the energy impressed upon said circuit to vary said space current, said variations being of the frequency of said carrier current but having greater amplitudes, the amplification varying in accordance with the variations of said low frequency current.

4. The method of modulating a high frequency carrier current by means of a space discharge amplifier having an input circuit and an output circuit, the amplifying power of which varies with the energy supplied to the input circuit, which comprises generating a high frequency carrier wave, generating a low frequency wave, and impressing said high frequency wave and said low frequency wave simultaneously and in series upon the input circuit of the amplifier.

5. The method of modulating high frequency carrier current which consists in producing a high frequency carrier wave, simultaneously producing a low frequency wave of greater amplitude than said high frequency wave and variably amplifying said high frequency wave in accordance with said low frequency wave.

6. The method of modulation which consists in generating a high frequency wave, simultaneously generating a low frequency wave having an amplitude at least as great as that of said high frequency wave and variably amplifying said high frequency wave in accordance with said low frequency wave.

7. The method of operating a thermionic amplifier having a cathode, an anode, a space current control means, input and output circuits and a source of space current in said output circuit, which method comprises simultaneously impressing upon said control means a series of high frequency waves and a series of low frequency waves and a constant potential, and so adjusting the apparatus that the space current in said output circuit periodically falls to substantially zero value.

8. The method of signaling which comprises generating a series of waves and subsequently simultaneously amplifying and modulating each of the waves in accordance with a signal.

9. In a system for radio-transmission, a source of high frequency oscillations, an amplifier having an input circuit and an output circuit, means for impressing said high frequency oscillations on said input circuit, a primary source of low frequency currents, and a path of variable impedance in said output circuit controllable by said low frequency currents.

10. In a system for radio-transmission, a source of high frequency oscillations, an amplifier for said oscillations having an in-

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put circuit, and a primary source of low frequency currents connected with said input circuit whereby the amplification of said oscillations is made to vary in conformity with variations in said low frequency currents.

11. In a system for radio-transmission, a thermionic amplifier having an input circuit, a source of high frequency oscillations connected with said input circuit, and a primary source of low frequency electromotive force also connected with said input circuit.

12. The combination with a source of low frequency currents, of a source of high frequency oscillations, means for amplifying said oscillations comprising an evacuated vessel containing an electron-emitting cathode, an anode and an auxiliary electrode, an input circuit including said cathode and said auxiliary electrode, means for impressing said oscillations on said input circuit, and a connection between said low frequency current source and said input circuit in series with said means.

13. The combination with a source of low frequency signal impulses, of a generator of high frequency oscillations, means for amplifying said oscillations comprising a thermionic repeater having an input circuit and an output circuit, a high frequency transformer having its primary connected to said generator and its secondary included in said input circuit, a low frequency transformer having its primary connected to said low frequency source and having its secondary connected to said input circuit in series with the secondary of said high frequency transformer.

14. The combination with an electric discharge device having main electrodes and an impedance controlling means, of an output circuit for said device, a source of current in said output circuit, and means for simultaneously impressing upon said controlling means high frequency waves and low frequency waves, auxiliary means for impressing a substantially constant pressure upon said controlling means, the relative amplitudes of the waves and the constant pressure being such that the discharge current periodically falls to substantially zero value at the frequency of said low frequency waves.

15. The combination with an amplifier having the property of variably amplifying in accordance with the energy impressed thereupon, of a circuit for impressing energy upon said amplifier, means for simultaneously impressing high frequency waves and low frequency waves upon said circuit, the amplitude of said high frequency waves being less than the amplitude of said low frequency waves.

16. The combination with an amplifier having the property of variably amplifying in accordance with the energy impressed thereon, of means for simultaneously impressing high frequency waves and low frequency waves upon said amplifier, said waves of low frequency having an amplitude at least as great as that of said waves of high frequency.

17. In a modulating system, the combination with a source of high frequency oscillations, of means for modulating said oscillations, said means comprising a device asymmetrically conducting for said high frequency oscillations and an impedance varying element therefor, said means being free from contact resistance.

18. The combination with a space discharge device, of a source of space current therefor, a source of carrier waves acting upon said device, a source of low frequency signaling waves acting upon said device, means associated with said device for causing said carrier waves to impress variations of their own frequency upon said space current, and means for transforming said variable current into alternating current of carrier frequency modulated in accordance with said low frequency signaling waves.

19. The combination with a source of high frequency waves, a source of low frequency waves, a source of space current, and means for varying an impedance presented to said space current, said means being controlled by both the high and the low frequency waves, and means whereby the effect of said high frequency waves upon the impedance presented to said space current is varied periodically by said low frequency waves.

20. In a high frequency signaling system, a source of high frequency oscillations, and a power amplifier having a curved characteristic for modulating and amplifying said oscillations in accordance with a signal.

21. In a transmission system, a source of high frequency oscillations, power amplifying means for modulating said oscillations and means for impressing said high frequency oscillations upon said amplifying means, the amplifying power of said means being substantially independent of the amplitude of the impressed high frequency oscillations.

22. In a modulating system, the combination with a source of high frequency oscillations, of means for modulating said oscillations, said means comprising a space discharge device and an impedance varying element therefor, said means being free from contact resistance.

23. The combination with an electric discharge device having main electrodes and an impedance-controlling means, of an input circuit and an output circuit each connected to said device, a source of high frequency

electromotive force, a source of low frequency electromotive force, means for connecting each of said sources to said input circuit, said connecting means substantially preventing either of said sources from affecting the electromotive force impressed by the other, and said device having an amplifying power substantially proportional to the amplitude of the impressed low frequency electromotive force.

24. The combination with a modulator having an input circuit of high impedance, of means for impressing high frequency impulses upon said circuit, means in series with said last-mentioned means for impressing low frequency impulses upon said circuit, and means to reduce the impedance effect of one of said means upon the impulses impressed upon said circuit by the other of said means.

25. The combination with a modulator having an input circuit of high impedance, of a transformer for impressing high frequency impulses upon said circuit, a second transformer in series with said first-mentioned transformer for impressing low frequency impulses upon said circuit, a resistance element in series with said transformers in said circuit, and a second resistance element in parallel circuit arrangement with said first resistance element and one of said transformers.

26. In a system of communication, a generator providing a source of high frequency oscillations, a source of signal oscillations, an asymmetrically conducting thermionic device having a constantly active source of electrons, an input circuit and an output circuit, means for impressing oscillations from both of said oscillation sources upon the input circuit of said thermionic device, and a high frequency transmission circuit associated with the output circuit of said device.

27. The method of producing modulated waves, which comprises producing a carrier wave, amplifying said carrier wave and simultaneously varying the amplification of said carrier wave so as to make it substantially proportional to the amplitude of a low frequency wave.

28. The method of producing modulated waves which comprises producing a carrier wave, amplifying said carrier wave and simultaneously controlling the amplification of said carrier wave substantially exclusively in accordance with a low frequency wave.

29. The method of producing modulated waves which comprises impressing a carrier wave upon an amplifier to produce an amplified carrier wave and simultaneously impressing upon said amplifier another wave of much larger amplitude than said impressed carrier wave in order to control the magnitude of the amplified carrier wave.

30. The method which comprises simultaneously subjecting a thermionic device having a variable amplifying power to the action of a high frequency wave, and a low frequency wave, the amplitude of the high frequency wave being insufficient to cause considerable change in the amplifying power of said amplifier and the amplitude of the low frequency wave being sufficient to cause large change in the amplifying power of said amplifier.

31. The method of operating a thermionic discharge device having a cathode, an anode and an impedance control element, an input circuit connected to said cathode and said impedance control element and an output circuit connected to said cathode and said anode, which method comprises impressing a high frequency electromotive force upon said input circuit, simultaneously impressing an electromotive force between said control element and said cathode, negatively directed with respect to said control element, and varying at a low frequency rate the effective value of said negatively directed electromotive force.

32. The method of producing a modulated wave which comprises impressing a carrier wave upon a thermionic amplifier having a curved characteristic and simultaneously impressing upon said amplifier an electromotive force varying at a low frequency and of a magnitude within a range throughout which the curved characteristic is substantially parabolic.

33. In combination, means for producing a carrier wave, means connected thereto for amplifying said carrier wave, means for producing a low frequency wave connected to said amplifying means and means associated therewith whereby the amplification of said carrier wave may be made substantially proportional to the amplitude of said low frequency wave.

34. In combination, means for producing a carrier wave, means connected thereto for amplifying said carrier wave, means connected to said amplifying means for controlling the amplification of said carrier wave substantially exclusively in accordance with a low frequency wave.

35. Means for producing a carrier wave, an amplifier connected to said means, and means for impressing upon said amplifier another wave of amplitude large compared with that of said impressed carrier wave in order to control the magnitude of the amplified carrier wave.

36. In combination, an amplifier having a variable amplifying power, a high frequency source and a low frequency source, means connecting said sources to said amplifier to simultaneously impress thereon high frequency waves and low frequency waves, the amplitude of the impressed high fre-

quency waves being insufficient to cause considerable change in the amplifying power of said amplifier and the amplitude of the impressed low frequency waves being sufficient to cause large change in the amplifying power of said amplifier.

37. A thermionic discharge device having a cathode, an adode and an impedance control element, an input circuit connected to said cathode and said control element, an output circuit connected to said cathode and anode, a high frequency source connected to said input circuit, means for impressing a negative electromotive force upon said control element with respect to said cathode, and means for varying at a low frequency rate the effective value of said negative electromotive force.

38. In combination, a thermionic amplifier having a curved characteristic, means for impressing thereon a carrier wave, means for simultaneously impressing upon said amplifier an electromotive force varying at low frequency and having an amplitude within a range throughout which said curved characteristic is substantially parabolic.

In witness whereof, I hereunto subscribe my name this 20th day of August, A. D., 1915.

HENDRIK JOHANNES VAN DER BIJL.

Corrections in Letters Patent No. 1,350,752.

It is hereby certified that in Letters Patent No. 1,350,752, granted August 24, 1920, upon the application of Hendrik Johannes van der Bijl, of New York, N. Y., for an improvement in "High-Frequency Signaling," errors appear in the printed specification requiring correction as follows: Page 3, line 53, claim 1, for the word "invariably" read *in variably* (two words); page 6, line 8, claim 37, for the word "adode" read *anode*; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 30th day of November, A. D., 1920.

[SEAL.]

L. B. MANN,

Acting Commissioner of Patents.

Cl. 177—171.

1514

L. DE FOREST.

MEANS FOR AMPLIFYING CURRENTS.

APPLICATION FILED JUNE 24, 1913.

1,375,447. **Patented Apr. 19, 1921.**

2 SHEETS—SHEET 1.

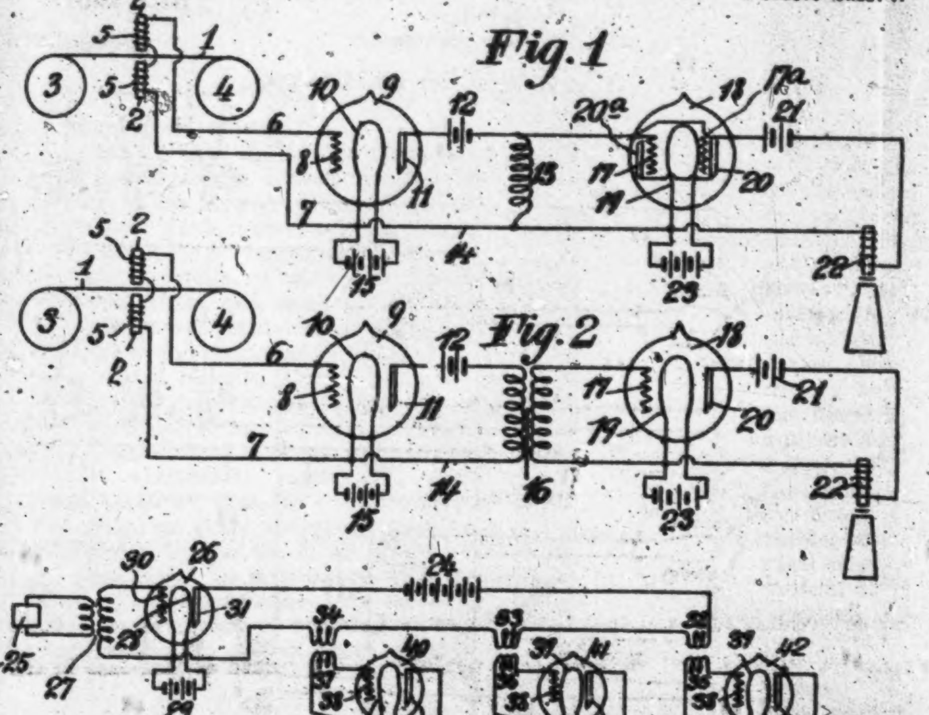

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Witnesses:

Lee de Forest Inventor

By his Attorneys

1515

L. DE FOREST.
MEANS FOR AMPLIFYING CURRENTS.
APPLICATION FILED JUNE 24, 1913.

1,375,447.

Patented Apr. 19, 1921.

2 SHEETS—SHEET 2.

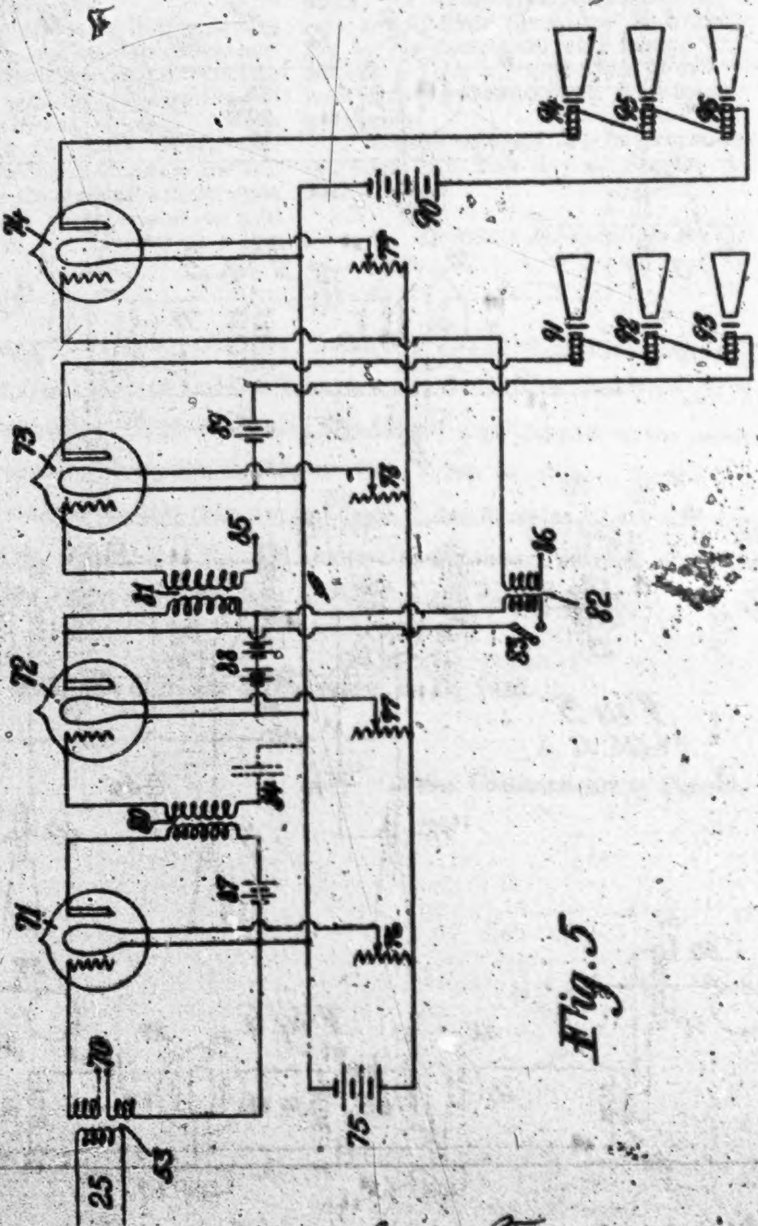

Fig. 5

Witnesses:
E. W. Nicol

Lee de Forest Inventor

By his Attorneys

UNITED STATES PATENT OFFICE.

LEE DE FOREST, OF NEW YORK, N. Y., ASSIGNOR, BY MESNE ASSIGNMENTS, TO DE FOREST RADIO TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF DELAWARE.

MEANS FOR AMPLIFYING CURRENTS.

1,375,447. Specification of Letters Patent. Patented Apr. 19, 1921.

Application filed June 24, 1912. Serial No. [illegible].

To all whom it may concern:

Be it known that I, LEE DE FOREST, a citizen of the United States, residing at New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Means for Amplifying Currents, of which the following is a full, clear, and exact specification.

This invention relates to the method of and apparatus for reproducing sounds from magnetic sound records, and to the art of reproducing magnetic sound records.

More specifically, my invention contemplates the emission of sounds by apparatus, preferably electrically controlled, from magnetic material, such as a telegraphone wire or strip, or other recording material, and preferably by the use of an audion, or audion amplifier. In accordance with my invention, the telegraphone wire or other magnetic sound record is operated in suitable relationship to one or more magnets controlling an electrical circuit, whereby the magnetic variations corresponding to the recorded sounds, are transformed into electrical "sound" currents, which in turn are transformed into sound by means of a telephone receiver, a "loud-speaking" reproducer, or the like. I also contemplate the reproduction of sounds at a plurality of different locations and more or less remotely situated from the telegraphone wire or other recording material, or other magnetized sound record, and coöperating magnet or magnets. In such form of my invention, I have found it desirable to employ a master audion for electrically controlling individual audions which are connected respectively in or control the various circuits of the various telephone receivers, "loud-speaking" reproducers, or other means for reproducing sounds at the different locations. I also contemplate transferring a record from one telegraphone wire to another, by the use of one or more audions, and coöperating circuits.

Other objects and features of my invention will be understood from the following description, and the accompanying drawings, in which—

Figure 1 represents one form of my apparatus for carrying out my invention, wherein two audions are combined for reproducing sounds recorded on a telegraphone wire;

Fig. 2 is similar to Fig. 1, except that the circuits of the audions are associated by means of a two coil transformer, instead of an auto-transformer.

Fig. 3 shows my method and apparatus for reproducing sounds at a number of different locations from a single telegraphone record;

Fig. 4 shows one form or arrangement for carrying out my method of transferring a sound record from one telegraphone wire to another telegraphone wire; and

Fig. 5 indicates another method and apparatus for carrying out my method of reproducing sounds at a plurality of locations from a single telegraphone wire.

Referring to Figs. 1 and 2, the telegraphone wire 1 is indicated as brought in suitable proximity to the magnets 2, 2. For such purpose, the telegraphone wire may be moved at a suitable speed, such as by winding the wire 1 off of the reel 3 and onto the reel 4 by suitable mechanism, as will be understood. The magnets 2 comprise windings 5, 5, preferably of fine wire, arranged either in series or in parallel in the circuit comprising the conductors 6, 7. The conductor 6 is shown connected to the grid 8 of the audion 9, and the conductor 7 is shown connected to one terminal of the filament 10 of audion 9. The plate or "wing" 11, as indicated in Fig. 1, of audion 9 is connected through the source 12, reactance or bridging coil 13 and conductor 14 to the filament 10. The filament 10 is shown as provided with a control circuit including the source 15. The grid 17 of audion 18 is connected to one terminal of the reactance or auto-transformer 13, the other terminal of the reactance 13 being connected to one terminal of the filament 19 of audion 18, which terminal of the filament 19 is connected to the plate or "wing" 20, of audion 18, through the operating or controlling magnetic coil 22 of the telephone receiver, megaphone, or "loud-speaking" reproducer and the source 21. The filament 19 of audion 18 is connected to the source 23 in a separate circuit, which will be controllable with respect to voltage and amperage. The sources 15 and 23 are preferably storage batteries, and if desired, the two filaments may be energized by a common source, such as a storage battery. The filaments 10 and 19 may be of any suitable material which be-

comes incandescent at the desired temperature; I prefer to employ filaments of tantalum ordinarily, since the same gives excellent results under the usual conditions of operation. The plates or "wings" 11, 20 are preferably made of nickel, or the like. In the arrangement shown in Fig. 1, the coil 13 serves as the bridging coil of the two audion circuits, as well as functions as impedance, and may be adjusted for varying impedance.

It will be noted that Fig. 2 shows a two coil transformer 16 instead of the reactance or auto-transformer 13, and the "wing" or plate 11 of audion 9 connected to one terminal of the filament 10 through the primary coil of transformer 16. The grid 17 of audion 18 is shown connected to one terminal of the secondary of the two coil transformer 16, the other terminal of said secondary being connected to one terminal of the filament 19. In the case of either the auto-transformer of Fig. 1, or the two-coil transformer of Fig. 2, the action is the same, the function is the same and the result is the same. In both cases an electrical association is thereby accomplished between the plate element of the one audion and the grid element of the other audion, and each serves to supply reactance.

I prefer, in the arrangement shown in Fig. 2, to employ a one-to-one ratio transformer. The primary, or secondary, or both, may be constructed to be adjustable.

From the above, it will be clear that the magnetic variations recorded in the telegraphone wire 1 will be reproduced electrically in the form of weak undulatory electric currents or impulses in the fine-wire windings 5, 5 of magnets 2, 2 and thus amplified by the audion 9, which electrical amplifications are further amplified by the audion 18, and thereby reproduce sounds in the telephone receiver, megaphone or "loud-speaking" reproducer, corresponding to the original sounds recorded magnetically on the telegraphone wire 1. By suitably controlling the temperature or energization of the filaments 10 and 19, the amplification will be regulated and tonal quality of the sounds controlled.

In Fig. 3, I have illustrated one form of my invention for reproducing sounds at a plurality of points distant from the point of location of a source of weak electric pulsating currents desired to be amplified, such as telegraphone currents, etc. The source of weak electric pulsating curents is schematically indicated at 25, and electrically connected to the master audion 26 through the two-coil transformer 27. The filament 28, preferably of tantalum, is shown energized by the source 29, such as a storage battery. The grid 30 is connected to one terminal of the transformer 27, and the plate or "wing" 31 is connected in circuit with the source 24, and in series with the primaries 32, 33, 34, etc., of the various transformers controlling the various circuits leading to the different points at which the sounds, or other indications, are reproduced. The secondaries 35, 36, 37, etc., are seen respectively connected to the grids 38 and one terminal of the respective filaments 39 of the secondary audions 40, 41, 42, etc. As shown, the filaments 39 may be controlled by a common source, such as the storage battery 43, in which case I prefer to interpose the reactances or choke coils 44 between the respective terminals of the filaments 39, to thereby prevent inter-action between the secondary audions. The plates or "wings" 45 of the auxiliary audions are connected in the respective separate circuits comprising the source 46 and operating or controlling coil 47 of the telephone receiver, "loud-speaking" reproducer, megaphone, etc. In the arrangement shown in Fig. 3, the transformer 27 is preferably a step-up transformer to raise the voltage of the pulsating current derived at 25. The master audion 26 operates to amplify the pulsations, which are transmitted by the transformer 27 to respective primaries 32, 33, 34 of the auxiliary audion circuits; the amplified pulsating currents are further amplified by the separately controlled auxiliary audions to produce the desired intensity of quality of tone or sound emitted by the telephone receiver 47, or the like. The transformers 32, 35,—33, 36,—34, 37,—are preferably one-to-one two-coil transformers. It will be understood that the reactances or choke coils 44 may be of the adjustable type, or may be of the fixed type having a predetermined reactance. It will be clear that the telephone receivers, or the like, may be located at points remote from one another as may be desired. If a high amplification of sound is desired, two or more telephone receivers, or the like, may be connected in series in the same circuit.

In Fig. 4, I illustrate the reproducing of a magnetic sound record on one or more telegraphone wires, to thereby obtain duplicate records. The master or original telegraphone wire 50 is indicated as operated at the desired speed in suitable proximity to the telegraphone magnets 51. The magnets 51 are electrically connected to the audion, as by means of the transformer 53. The reactance 54 is connected across the line between the audion 52 and the auxiliary audion 55, the latter controlling the operating magnets 56 of the telegraphone 57, as by means of the transformer 58. The transformer 53 may be a step-up transformer, and the transformer 58 may be a step-down transformer, although I may make use of a one-to-one two-coil transformer. Thus, the

pulsating currents induced in the magnets 51, 51, will be amplified by the master audion 52 and by the auxiliary audion 55, thereby producing magnetic variations in the field of the magnets 56 of the telegraphone 57 to thereby obtain a suitable magnetic record in the wire 59.

In the particular arrangement shown, the primary of the transformer 53 is connected in series with the fine-wire windings of the magnets 51, 51, and the terminals of the secondary of transformer 53 are respectively connected to the grid 60 of audion 52 and to one terminal of the filament 61, said filament being preferably of tantalum. The source 62 is connected to control the energization of the filament 61. The "wing" or plate 63 of audion 52 is connected through the source 64 to one terminal of the reactance 54, the other terminal of reactance 54 being connected to the terminal of the filament 61 to which one terminal of the secondary of transformer 53 is connected. The grid 65 of audion 55 is connected through the reactance 54 with one terminal of the filament 66 of audion 55, said terminal being also connected to a terminal of the primary of transformer 58. The remaining terminal of primary of transformer 58 is connected to the source 67 and "wing" or plate 68 of audion 55. The filament 66 is shown controlled by a separate source 69; however, if desired the filaments 61, 66, may be energized by a common source and suitably controlled to obtain the desired joint and individual functions.

It will also be clear that a plurality of telegraphones may be associated with respective auxiliary audions and a master audion, similar to the arrangement shown in Fig. 3, and thereby secure the simultaneous production of a plurality of duplicate magnetic sound records.

In accordance with the arrangement shown in Fig. 5, the weak pulsating currents are transmitted by circuit 25 through the primary of transformer 53, the secondary of which controls one or more master audions 71, 72, which in turn control local circuits, each comprising an auxiliary audion controlling a suitable sound reproducing device. I have found that it is advantageous to form the secondary of transformer 53 of one or more coils electrically interrupted by an open-circuited gap 70. If desired, a condenser may be connected between the terminals of the conductors between which the gap exists; however, under the usual conditions, a condenser is not necessary. The secondary of transformer 53 is connected to the grid element of audion 71 and also to one terminal of the filament of audion 71, the "wing" element of audion 71 being connected through primary of transformer 80 and battery 87 to said terminal of the filament 71. One terminal of secondary of transformer 80 is connected to the grid of audion 72, and the other terminal open-circuited, or, if desired, connected to a condenser 84 and to one terminal of the filament of audion 72. However, I have found it desirable under usual conditions to omit the condenser 84 and the said connection with the filament of audion 72. The auxiliary audions 73, 74, etc., are connected in the respective local circuits and controlled by the master audions 71, 72, preferably through one-to-one two-coil transformers 81, 82, the primaries of which are electrically related in parallel. I prefer to interrupt or open-circuit one of the connections of the primaries of transformers 81, 82, to thereby secure an open-circuited gap, such as that indicated at 83. The source of electrical energy 88, such as a storage battery, is shown connected between the primaries of transformers 81, 82, and one terminal of the filament of audion 72. The battery 88 may be connected between the "wing" element of audion 72 and the primary of the transformers 81, 82. However, the interposition of the battery 88 between the filament and the primary coils of transformers 81, 82, secures superior sensitiveness and more uniform amplification for wide ranges of tone and quality of sounds. Similarly, the connection of source or battery 87 between the primary of transformer 80 and the filament of audoin 71, is preferable, under usual conditions of operation, as compared with the interposition of the souce 87 between the primary of transformer 80 and the "wing" element of audion 71.

The secondary of transformer 81 is connected at one end to the grid element of auxiliary audion 73, the other end of secondary 81 being open-circuited at 85. The secondary of transformer 82 is similarly connected at one end to the grid of auxiliary audion 74, and open-circuited at its other end, as indicated at 86. The local circuit of auxiliary audion 73 is shown embodying three electromagnetic sound reproducers 91, 92, 93, the coils of which are connected in series and further connected to the "wing" of audion 73, battery 89 and to one terminal of the filament of audion 73. Similarly, the three electroresponsive sound reproducers 94, 95, 96, arranged in series, are connected to the "wing" element of audion 74, battery 90 and to one terminal of the filament of audion 74.

The respective filaments of master audions 71, 72, and of auxiliary audions 73, 74, are shown energized by a common source of electrical energy 75, such as a storage battery, and respectively controlled by adjustable resistances 76, 77, 78, 79.

It will be clear that but a single local circuit and auxiliary audion amplifier may be used, and actuated and controlled in ac-

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cordance with the arrangement indicated in Fig. 5; likewise, three or more local circuits having individual audion amplifiers may be connected and controlled by transformers arranged in parallel with respect to a master audion. When a plurality of electromagnetic sound reproducers are employed on a local circuit, such reproducers may be positioned at different locations in a room or auditorium, whereby sounds of any desired amplification and of highly satisfactory quality will be reproduced even from as feeble a source as a telegraphone wire. I have secured excellent results in the operation of my arrangement indicated in Fig. 5 without the use of condensers at the open-circuit gaps indicated, although it is feasible to obtain amplified sounds from a telegraphone wire by the use of condensers at said open-circuited gaps. It is advantageous to arrange the grids of the several audions so that the same are not connected to a source of direct current electromotive force, and thereby markedly improve the sensitiveness of the apparatus.

I have discovered that the sensitiveness of the audion is improved by employing a plurality of grids and a plurality of wings, preferably by disposing each grid between a wing and the filament. In the audion 18, see Fig. 1, I have indicated a record grid 17ª disposed between the wing 20 and the filament 19, and a second wing 20ª disposed to one side of the grid 17 and opposite the filament 19, so that the grid 17 is disposed between the wing 20ª and filament 19. In a similar manner, the audions, each or all, as desired, may be provided with a plurality of grids and a plurality of wings, and thereby improve the sensitiveness of operation of the respective arrangements indicated in Figs. 1 to 5, inclusive.

From the above, it will be seen that my method and apparatus contemplates the transmission of relatively weak electric pulsating currents which are amplified by the use of an audion, the amplification of which is controlled independently of the strength, frequency, amplitude, etc., of the pulsating currents. Whereas, I have illustrated particular forms of my apparatus and wherein my method may be carried out, it will be understood that modifications and changes may be made therein without departing from the scope of my invention. The circuit leads from the source of the undulatory electric currents to the first audion may be regarded and termed line wire or receptor connections, and as shown, the current flow therein is unilateral. The audion bulbs, as shown, and as usual, are evacuated vessels in each of which are disposed the filament, the plate or "wing" and the grid. In operation each filament is a cathode and when heated from the source of current in circuit therewith emits negative ions. Each plate or "wing" is an anode and the function of the grids is to form a screen. By impressing undulatory electric currents upon the grids, as, for instance, by connecting the source of undulatory current or the receptor lead thereto, or by connecting electrically the grid or screen of one audion with the plate or anode of another, the potentials of the grids are varied correspondingly to the undulations of the currents so impressed thereon. Since the audion bulbs are evacuated the elements disposed therein are surrounded by a gaseous conducting space, and it is in this space between the cathode and anode elements that the ionization takes place when the cathode or filament is heated thereby forming a conducting path between the cathode and anode and in the local circuit which includes these elements and also a source of external unidirectional electro-motive force such as the batteries 12, 24, 64, 87, 88, 89, 90. These batteries, of course serve to maintain a difference of potential between the anodes and screens or other elements to which their terminals are connected.

In the case of Figs. 3, 4, and 5, the secondaries of transformers 27 and 53 are connected at their respective terminals to the grip or screen and filament or cathode elements, respectively, of their associated audion bulbs through leads or receptor connections in the same way as in the case of the leads 6, 7, of Figs. 1 and 2.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent of the United States is:—

1. The combination with a source of weak undulatory current, of an electric circuit including a source of current, means to vary the conductivity of said circuit by and in accordance with said undulatory current, a reactance connected across said circuit, and an audion conductively connected with said circuit.

2. The combination with a source of weak undulatory current, of a vessel having therein an anode and a cathode separated from each other, and a grid or screen, said source of undulatory current being connected to said grid or screen to vary the conductivity of the space between said anode and cathode by and in accordance with said undulatory current, a circuit including therein said anode and cathode, and a source of current, a second vessel containing a cathode and anode and a grid or screen, said circuit being conductively connected to said second grid or screen, a second circuit including therein said second anode and cathode and a separate source of current, and a translating device associated with said second circuit.

3. Apparatus for receiving or relaying

electric signals, having, in combination, an evacuated vessel, a cathode having provision for emitting negative ions, and an anode and its screen inclosed in said vessel, a second evacuated vessel, a second cathode having provision for emitting negative ions, and a second anode, means for conducting signal impulses to the first screen to vary its potential, a local circuit including a source of electromotive force and a conductive electrical connection between the first anode and second screen, and a second circuit having a connection with a signal indicating device and including a source of electromotive force and a connection between the second cathode and second anode.

4. Apparatus for receiving or relaying electric signals, having, in combination, at least one cathode, having provision for emitting negative ions, an anode, a screen in proximity to the anode, a second anode, a second screen in proximity to the second anode, said elements being surrounded by gaseous conducting space, means for conducting the electric signal impulses to the first screen to vary its potential, a local circuit including a source of electromotive force and a conductive electrical connection between the first anode and second screen, and a second circuit connected with a signal indicating device and including a source of electromotive force and a connection between the second anode and a cathode.

5. Apparatus for receiving or relaying electric signals, having, in combination, at least one cathode, a plurality of anodes and screens therefor, said elements being surrounded by gaseous conducting space, a receptor connection to one screen, a conductive electrical connection between another screen and an anode, and a connection from another anode and a cathode to a signal indicating device.

6. Apparatus for receiving or relaying electric signals, having, in combination, an evacuated vessel, a cathode, anode and screen inclosed therein, a second evacuated vessel and a second cathode, anode and screen inclosed therein, a receptor connection to the first screen, a conductive electrical connection between the second screen and first anode, and a connection from the second anode and second cathode to a signal indicating device.

7. Apparatus for receiving or relaying electric signals, having, in combination, at least one cathode having provision for emitting negative ions, an anode, a screen in proximity to the anode, a second anode, a second screen in proximity to the second anode, said elements being surrounded by gaseous conducting space means for varying the potential of the first screen in response to the received signal impulses, means including a conductive electrical connection from the first anode to the second screen and an internal unidirectional source of electromotive force in the connection for maintaining a difference of potential between the second screen and first anode and having provision for causing variations in the potential of the second screen corresponding to variations in the potential of the first screen and means having a connection with a signal indicating device for causing an electric current to flow between the second anode and a cathode.

8. Apparatus for receiving or relaying electric signals, having, in combination, an evacuated vessel, a cathode having provision for emitting negative ions and an anode and its screen inclosed in said vessel, a second evacuated vessel, a second cathode having provision for emitting negative ions and a second anode and its screen inclosed in said second vessel, means for varying the potential of the first screen in response to the received signal impulses, means including an external unidirectional source of electro-motive force for maintaining the second screen at a different potential from the second cathode and having provision for causing variations in the potential of the second screen corresponding to variations in the potential in the first screen, and means having a connection with a signal indicating device for causing an electric current to flow between the second anode and the second cathode.

9. Apparatus for receiving or relaying electric signals having, in combination at least one cathode having provision for emitting negative ions, an anode and its screen, a second anode and its screen, said elements being surrounded by gaseous conducting space, a connection to the first screen for causing variations in its potential corresponding to the received signal impulses, a local circuit including a connection between the first anode and second screen and a source of electromotive force for maintaining a difference of potential between the second screen and first anode, and a connection between the second anode and a cathode including a source of electromotive force.

10. Apparatus for receiving or relaying electric signals, having, in combination, an evacuated vessel, a cathode having provision for emitting negative ions and an anode and its screen inclosed therein, a second evacuated vessel, and a second cathode having provision for emitting negative ions and an anode and its screen inclosed therein, a connection to the first screen for causing variations in its potential corresponding to the received signal impulses, a local circuit including a connection between the first anode and second screen and a source of electromotive force for maintaining a second screen at a potential negative with respect to the

second cathode, and a connection between the second anode and second cathode including a source of electromotive force.

11. Apparatus for receiving or relaying electric signals, having in combination, at least one cathode having provision for emitting negative ions, a plurality of anodes and their screens, a receiving connection to one screen, a conductive electrical connection between another screen and the anode which is adjacent the first screen, and a connection from another anode and a cathode to a signal indicating device.

12. Apparatus for receiving or relaying electric signals, having, in combination, an evacuated vessel, a cathode having provision for emitting negative ions, and an anode and its screen in proximity to the cathode inclosed within said vessel, means for maintaining the screen at a negative potential with respect to the cathode by a current supplied through a similar evacuated vessel and for superimposing on said negative potential variations in potential corresponding to the signal impulses and means including a connection to a signal indicating device for causing an electric current to flow between the cathode and anode.

13. Apparatus for receiving or relaying electric signals, having, in combination an evacuated vessel, a cathode having provision for emitting negative ions and an anode and its screen adjacent the cathode inclosed within said vessel, means tending to cause a current to flow between the anode and the cathode, means including a source of electromotive force and a partly gaseous path for normally maintaining the screen at a potential negative with respect to the cathode, and means for causing variations in the potential of the screen corresponding to the signal impulses.

14. Apparatus for receiving or relaying electric signals, having, in combination, an evacuated vessel, a cathode having provisions for emitting negative ions and an anode and its screen inclosed in said vessel, a second evacuated vessel, a second cathode having provision for emitting negative ions and a second anode and its screen inclosed in the second vessel, means for causing variations in the potential of the first screen corresponding to the signal impulses, a circuit across the evacuated space from the first cathode to the first anode, along a wire connection to the second screen, across the evacuated space from the second screen to an adjacent electrode and back along a wire connection to the first cathode, such circuit including a source of electromotive force tending to cause a negative current to flow from the first cathode to the first anode, and a second circuit across the evacuated space from the second cathode to the second anode, said circuit including a connection to a signal indicating device and a source of electromotive force for causing a negative current to flow from the second cathode to the second anode.

15. Apparatus for receiving or relaying electric signals, having, in combination, a local circuit including a source of electromotive force, an amplifier including a plurality of electrodes surrounded by a gaseous conductor, and connected with the local circuit and operating to produce impulses in the local circuit corresponding to but of greater intensity than the received signal impulses, a second circuit including a source of electromotive force and a connection with a signal detecting device, and a second amplifier including a plurality of electrodes surrounded by a gaseous conductor, said second amplifier being conductively electrically connected with both circuits and operating to amplify the current impulses in the second circuit corresponding to but of greater intensity than the impulses in the first local circuit.

16. Apparatus for receiving or relaying electric signals, having, in combination, a local circuit including a source of electromotive force, an amplifier including a cathode, anode and screen surrounded by a gaseous conductor, said amplifier having a connection from its anode and cathode to the local circuit and a connection for leading the received impulses to its screen and operating to produce impulses in the local circuit corresponding to but of greater intensity than the received signal impulses, a second circuit including a source of electromotive force and a connection to a signal detecting device, and a second amplifier including a cathode, anode and its screen surrounded by a gaseous conductor and having its cathode and anode connected to the second local circuit and its screen conductively electrically connected to the first local circuit and operating to amplify the impulses in the first local circuit to produce impulses in the second local circuit corresponding to but of greater intensity than in the first local circuit.

17. The combination, with the line wire, of apparatus for receiving or relaying electric signals transmitted over wires, comprising an evacuated vessel, a cathode, anode and its screen inclosed therein, and a unilateral connection between the apparatus and the line wire.

18. The combination, with the line wire, of apparatus for receiving or relaying electric signals transmitted over wires, comprising a cathode having provision for emitting negative ions, an anode, and its screen in proximity to the cathode, said elements being surrounded by a gaseous conductor, a connection between the cathode and anode including a source of electromotive force,

and a unilateral connection between the apparatus and the line wire consisting of a receptor lead connected to the screen.

19. The combination, with the line wire, of apparatus for receiving or relaying electric signals transmitted over wires, comprising an evacuated vessel, a cathode, anode and screen inclosed therein, a connection between the cathode and anode including a source of electromotive force, a transformer having its primary in series with the line wire, and a unilateral connection between the transformer and the apparatus consisting of a receptor connection from one terminal of the transformer secondary to the screen, the other terminal of the secondary being unconnected with the apparatus.

20. The combination with a magnetic sound record, means to generate an alternating electric current by and in accordance with said record, an audion having a filament, an anode and a grid disposed therein, a circuit connection to impress said alternating current upon said grid, an energizing circuit for the filament, a second audion having a filament, an anode and a grid, a circuit connection including the anode and filament of the first audion conductively connected to the grid and filament of the second audion, and a source of current, and a local circuit including the anode and filament of the second audion and a source of current.

21. The combination with a source of current, of a plurality of audions conductively connected in series, the input circuit of the first of said audions being associated with said source of current, and an independent source of current connected to the output electrode of each of said audions.

22. The combination with a source of current, of a series of audions, the input electrode of the first of said audions in the series being associated with said source of current, the output electrode of the first audion of the series being conductively connected to the input electrode of the next audion of the series, and a separate source of current for the output electrode of each of said audions.

23. The combination with a source of current, of a series of audions, the input electrode of the first of said audions in the series being associated with said source of current, the output electrode of the first audion of the series being conductively connected to the input electrode of the next audion of the series, a separate source of current for the output electrode of each of said audions, and a signal indicating device associated with the output electrode of the last audion of the series.

24. An electrical amplifying system comprising a vacuum tube device having anode and cathode electrodes, means for supplying a space current between said electrodes, means for controlling said space current in accordance with an impulse to be transmitted, an impedance in circuit with said electrodes, and an amplifier conductively connected to said impedance.

25. An electrical amplifying system comprising a vacuum tube device having an anode and a cathode, an impedance, means for supplying current through said impedance and between said electrodes, means for controlling said current in accordance with an impulse to be transmitted, an amplifier having an input circuit and an output circuit, said input circuit being conductively connected and responsive to the potential variations across said impedance, and a receiving device connected to said output circuit.

26. Means for amplifying the alternating current component of a unidirectional current comprising an electron discharge device having plate and grid circuits, one of said circuits containing a source of current to be amplified, and an impedance conductively included in the circuit of the source of current to be amplified and included in the grid circuit through which the current to be amplified is caused to flow.

27. Means for amplifying the alternating current component of a unidirectional current comprising an electron discharge device having plate and grid circuits, one of said circuits containing a source of current to be amplified, and a reactance conductively included in the circuit of the source of current to be amplified and included in the grid circuit through which the current to be amplified is caused to flow.

28. An electrical amplifying system comprising a vacuum tube device having anode and cathode electrodes, means for supplying a space current between said electrodes, means for controlling said space current in accordance with an impulse to be transmitted, a reactance in circuit with said electrodes, and an amplifier conductively connected to said reactance.

29. A multi-stage amplifier comprising a plurality of vacuum tube devices each having an anode, a cathode and a control circuit, another circuit comprising a source of current and a reactance connected to the anode and cathode of one of said devices, and a conductive connection from said reactance to the control circuit of another of said devices.

In testimony whereof I affix my signature, in presence of two witnesses.

LEE DE FOREST.

Witnesses:
HENRY J. LUCKE,
GEO. N. KERR.

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L. DE FOREST.
AUDION CIRCUIT.
APPLICATION FILED APR. 27, 1920.

1,377,405. Patented May 10, 1921.

Fig. 1.

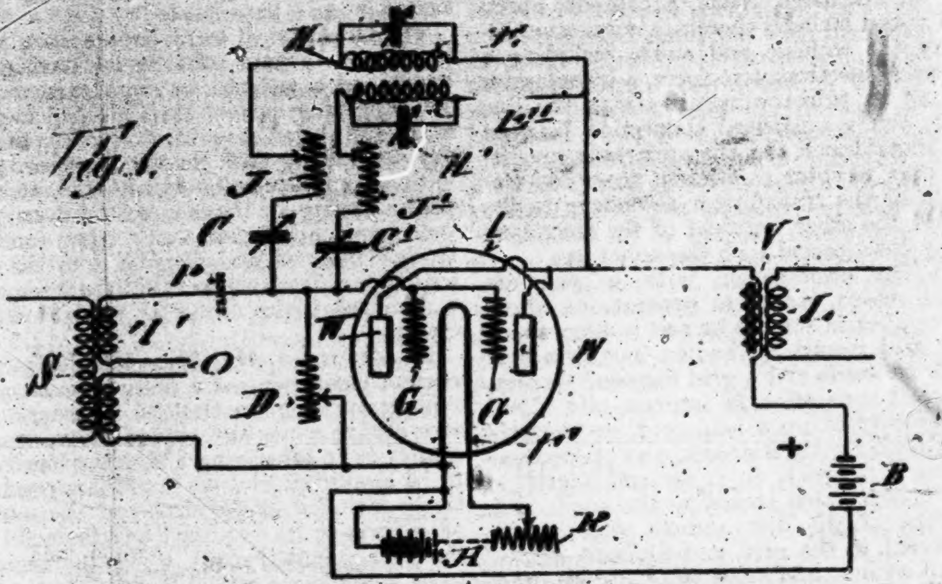
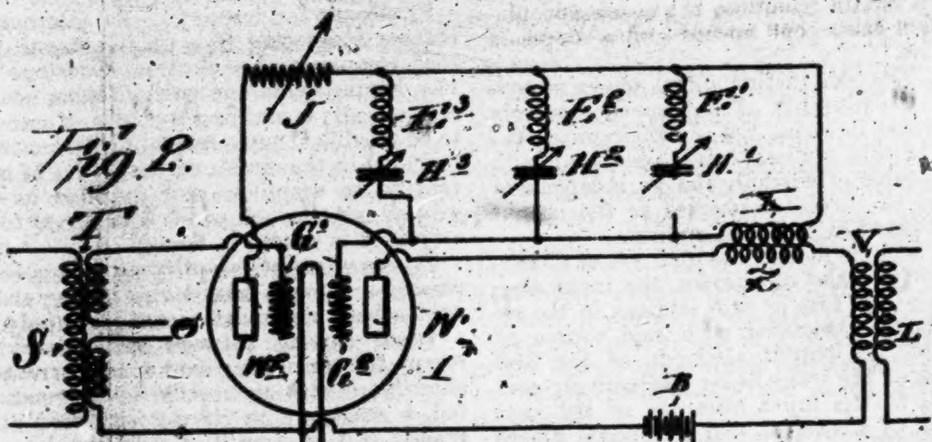


Fig. 2.



INVENTOR
Lee de Forest

BY his ATTORNEY Samuel E. Darby

UNITED STATES PATENT OFFICE.

LEE DE FOREST, OF NEW YORK, N. Y., ASSIGNOR TO DE FOREST RADIO TELEPHONE AND TELEGRAPH COMPANY, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE.

AUDION-CIRCUIT.

1,377,405. Specification of Letters Patent. Patented May 10, 1921.

Original application filed April 9, 1915, Serial No. 20,173. Divided and this application filed April 27, 1920. Serial No. 377,031.

To all whom it may concern:

Be it known that I, LEE DE FOREST, a citizen of the United States, residing at New York, county and State of New York, have made a certain new and useful Invention in Audion-Circuits, of which the following is a specification.

This invention relates to audion circuits, and is directed to subject matter divided from my co-pending application, Serial Number 20173, filed April 9, 1915, for selective audion amplifier.

The object of the invention is to provide an audion circuit which is simple and particularly adapted for amplification usage of the audion where the same is used as a relay as one illustration for either wire or, wireless purposes.

It has been found by experiment that relays of the audion type become paralysed when certain conditions in the normal operation exist. For example, where the device is used as an amplifier or relay with the current to be relayed and amplified received through an input circuit and the amplified current delivered by an output circuit, if the incoming current is excessive too large a charge upon the grid electrode of the audion causes the same to paralyse. Similarly, it frequently happens that a sudden signal impulse will effect the same result, namely, the paralysis of the audion. Also, if the plate current is excessive the effect of the paralysis is likewise produced. And if a critical adjustment of the plate and filament current sources is secured the normal incoming signal is apt to produce the paralysed condition of the audion. So it will be apparent that while the effect is the same, that is, the audion becomes paralysed, the causes of this condition of the audion may be any one of a number.

Where a perfect vacuum has not been obtained in the bulb this paralysed condition of the audion is frequently evidenced by a blue glow or haze although the paralysed-condition may frequently occur without any such visual evidence thereof, and is detected by the operator who at once generally knows that when the audion is not properly functioning it has become paralysed.

The special purpose of my present invention is to provide means for effectively preventing and overcoming this paralysed condition of the audion, and while I have shown and will now describe my invention as applied to an audion with all of the cathode and anode electrodes inclosed therein and as used as an amplifier or relay, I do not desire to be limited or restricted either to this construction or particular application of an audion.

Referring to the drawings,—

I show in Figure 1 one audion circuit arrangement embodying my invention, and which is a substantial duplication of Fig. 1, of my co-pending application above identified.

Fig. 2 shows a similar but slightly modified arrangement.

The same part is designated by the same reference numeral wherever it occurs throughout the several views.

Referring to Fig. 1, I show my present invention applied to a selective amplifier system of the audion type wherein the audion will perform its amplifying function selectively. In other words, incoming currents or currents of certain frequencies received by the audion will be amplified to a greater degree than currents of other frequencies, and especially currents of lower frequencies. In addition thereto, the principle of selective amplification can be emphasized as much as desired or necessary so that, if desired, the normal voice currents before going in to a telephone line, for example, can first be distorted and the higher harmonics thereof made of greater amplitudes so that after these latter currents are reduced in amplitude by the distributed capacity of the telephone line, the composite current will arrive at the distant receiving station in its normal or original form. This feature of selective amplification forms the subject matter of my application, Se-

rial No. [illegible] above identified, and does not form the subject matter of the present invention except in that the present invention is disclosed therein.

Reference character 1 designates an exhausted audion bulb, in this instance of the usual well known double plate and double grid structure both located within the bulb. It is apparent, however, that I do not desire to be limited with respect to the particular construction of the audion, or whether or not the electrodes are all located within the bulb or exterior thereof, as it is well known that audions vary somewhat in their construction and in the number of electrodes employed therein or therewith. As is customary, however, I have shown a filament electrode F which is heated from the current source A and controlled by the variable resistance R in the usual well known manner. The grid elements or input electrodes G, G, are preferably arranged on either side of the filament F and are connected in parallel. The wing or plate electrodes W, W, are also arranged on respectively opposite sides of the filament F and at a different distance therefrom relative to the grid electrodes, G, G. The incoming current to be amplified is led from the line to the primary coil S of a transformer T, preferably a step-up transformer. While I am not to be limited to the specific arrangement shown, I prefer to have the secondary coil of the transformer T wound in two parts disconnected from each other as shown at P, the parts thereof possessing a large capacity relative to each other. One end of one winding of the secondary coil of the transformer T is connected directly to the filament F of the audion 1, while one end of the other coil is connected to the grids G, G, of the audion 1. If desired, in the transformer and grid circuit, a condenser may be inserted, as shown in dotted lines at P. The plate or wing electrodes W, W, are connected through an inductance coil of a transformer V to one terminal, preferably the positive terminal of a source of current such as a battery B, the current, preferably the negative, terminal of which is connected to the filament F of the audion 1. The outgoing circuit L is connected to the secondary of the transformer V. An oscillating circuit consisting of the inductance E and capacity H in parallel thereto is connected by one terminal to the wing or plate electrodes W, W, and the other terminal to the grid electrodes G, G. If desired, and as shown, a capacity preferably in the form of a variable condenser C, may be inserted in this circuit. In accordance with my invention I insert a resistance J in this circuit, preferably in the lead to the grid electrodes G, G, and preferably, as shown, to make the resistance variable. By making the resistance variable I utilize the same in addition to the uses hereinbefore set forth as a damping resistance to reduce the amplitude of the potential surges delivered from the oscillating circuit H, E, to the grid electrodes, as above described.

The natural period of vibration of this oscillating or parasitic circuit depends to a great extent upon the amount of inductance of the coil E and the amount of the capacity of the condenser H. This frequency also depends upon the constants of the audion itself, the brightness of the filament F, the applied potential from the battery B, the amount of resistance J, and the amount of resistance D which forms a leak path between the grids G, G, and filament F, and is likewise made variable.

In addition to the first oscillating or parasitic circuit, if desired, a second similar circuit comprising elements C′, J′, E′, H′, identical with the corresponding elements of the first circuit may be connected between the grid and plate electrodes, but the oscillating circuit E′, H′, should be tuned to a different frequency or natural rate of oscillation than that of the first oscillating circuit. Similarly, a number of oscillating circuits, each tuned to a different frequency, can be connected to the audion.

It is not necessary, however, to connect such a parasitic or reinforcing circuit to the audion for each different frequency it is desired to amplify. I have found that one such circuit, the natural fundamental frequency of which may be such as to cause it to tend to oscillate approximately 1500 times per second, will cause incoming currents having frequencies considerably higher than 1500 to be amplified to almost the same degree, while at the same time not permitting currents having considerably lower frequencies to be thus auto-amplified. I have found that two such reinforcing circuits, the natural period of one of which is such as would cause the audion to deliver a sustained note of a frequency of about 1500 per second, if free to oscillate; and the natural period of the other of which is such as would cause the audion to deliver, if free to oscillate, a sustained note of about 2500 per second, will reinforce currents of all frequencies between 1200 and 3000 per second. It is therefore possible to arrange a single audion with reinforcing circuits to so selectively amplify voice currents that all the higher harmonics are amplified over those of the lower or fundamental frequencies.

The principles involved in enabling an audion to amplify different frequency currents unequally is set forth in my co-pending application above identified, from which the subject matter of this present application has been divided, and while I have gone rather fully into the description of the

selective amplifier circuit it should be remembered that my present invention is directed solely to the resistance leak path between the elements of the audion, and the full description of the selective amplifier has been given to enable a clear understanding of one application of my present invention to a specific system.

In Fig. 2 I have shown another circuit arrangement wherein the incoming currents are conducted to one of the grid electrodes as G', One of the wing or plate electrodes W' is connected to the outgoing line in the usual manner. The oscillating or "reinforcing" circuits are connected to the other electrodes W^2, G^2, of the audion bulb 1. Each of the oscillating circuits contains a common inductance X associated with the coil Z in the output circuit. The individual inductances E^1, E^2, E^3, etc., each in series with the capacity H^1, H^2, H^3, etc., respectively, determine the period of the reinforcing circuits, of which in this figure I have shown three. The effect of these reflection circuits associated with the output circuit is to impart to the audion the tendency to disproportionately amplify currents having frequencies generally approximately those of the three reinforcing circuits. In this arrangement the resistance J is inserted in the audion path of these circuits to prevent the audion from singing, and to afford a high resistance leak path as hereinbefore described.

From the foregoing it will be apparent that while it is preferable to connect the high resistance between the two cold electrodes, especially where the device is to operate as a relay, as shown in Fig. 2, the high resistance path may equally well be connected between either of the cold electrodes and the hot electrode, in the latter case preferably between the grid and filament.

Having now set forth the objects and nature of my invention, and having shown and described a construction embodying the principles thereof, what I claim as new and useful and of my own invention and desire to secure by Letters Patent is,—

1. An electric relay comprising an incoming circuit, an outgoing circuit including a gaseous conductor, forming a part of each of said circuits, and a conductive leakage path connected to two points in said gaseous conductor.

2. An electric relay comprising an incoming circuit, an outgoing circuit including a gaseous conductor forming a part of each of said circuits, and a high resistance conductive leakage path connected to two points in said gaseous conductor.

3. An electric relay comprising an evacuated vessel, a heated member, a conducting member and a conducting plate sealed therein, an incoming circuit connected across said heated member, and said conducting member, an outgoing circuit connected across said heated member, and said conducting plate, and an additional metallic circuit connecting said conducting member and said plate.

4. An electric relay comprising an evacuated vessel, an incoming circuit, an outgoing circuit, a cathode common to said circuits and anodes individual to said circuits sealed in said vessel, and a shunt circuit including a high resistance connecting said anodes.

5. An electric relay comprising an evacuated vessel, a heated electrode, a grid shaped member and a plate sealed therein, an incoming circuit including said heated electrode, a condenser and said grid member; an outgoing circuit including said heated electrode, a source of potential and said plate; and a shunt circuit including said grid member and said plate.

6. In an electric relay, the combination with an audion, of a circuit including a resistance in shunt of two of the elements of said audion.

7. An electric relay, comprising an incoming and an outgoing circuit, a gaseous conductor interposed between such circuits, and a conductive shunt circuit connected around said gaseous conductor.

8. An electric relay, an incoming circuit, an outgoing circuit including a gaseous conductor forming a part of each of said circuits and a conductive leakage path connected in parallel with a part of said gaseous conductor.

9. An electric relay comprising an evacuated vessel, a heated member, a conducting member and a conducting plate sealed therein, and a conductive circuit connected to said conducting member and said plate.

10. The combination with an evacuated vessel having associated therewith a hot and two cold electrodes, each of said cold electrodes being located at a relatively different distance from said hot electrode, electrical circuits connecting said electrodes, and a conductive leakage path connected to two of said electrodes.

11. The combination with an evacuated vessel having associated therewith a hot and two cold electrodes, each of said cold electrodes being located at a relatively different distance from said hot electrode, electrical circuits connecting said electrodes, and a high resistance conductive leakage path connected to two of said electrodes.

12. The combination with an evacuated vessel having associated therewith a hot and two cold electrodes, each of said cold electrodes being located at a relatively different distance from said hot electrode, electrical

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circuits connecting said electrodes, and a metallic resistance permanently connected between two of said electrodes.

12. The combination with an evacuated vessel having associated therewith filament, grid and plate electrodes, circuits connecting said electrodes, and a conductive leakage path connected between the grid and plate electrodes independent of the evacuated space between said grid and plate electrodes.

13. The combination with an evacuated vessel having associated therewith filament, grid and plate electrodes, circuits connecting said electrodes, and a high resistance leakage path connected between the grid and plate electrodes independent of the evacuated space between said grid and plate electrodes.

15. The combination with an evacuated vessel having associated therewith filament, grid and plate electrodes, circuits connecting said electrodes, and a metallic high resistance path permanently connected between the grid and plate electrodes.

16. The combination with an evacuated vessel having associated therewith filament, grid and plate electrodes, circuits connecting said electrodes, and an aperiodic circuit connected between two of said electrodes.

17. The combination with an evacuated vessel having associated therewith filament, grid and plate electrodes, circuits connecting said electrodes, and an aperiodic circuit connected between the grid and plate electrodes.

In testimony whereof I have hereunto set my hand on this 21st day of April, A. D. 1920.

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R. A. WEAGANT.

MEANS FOR GENERATING ELECTRICAL OSCILLATIONS.

APPLICATION FILED APR. 9, 1914.

1,384,108. **Patented July 12, 1921.**

Fig. 1.

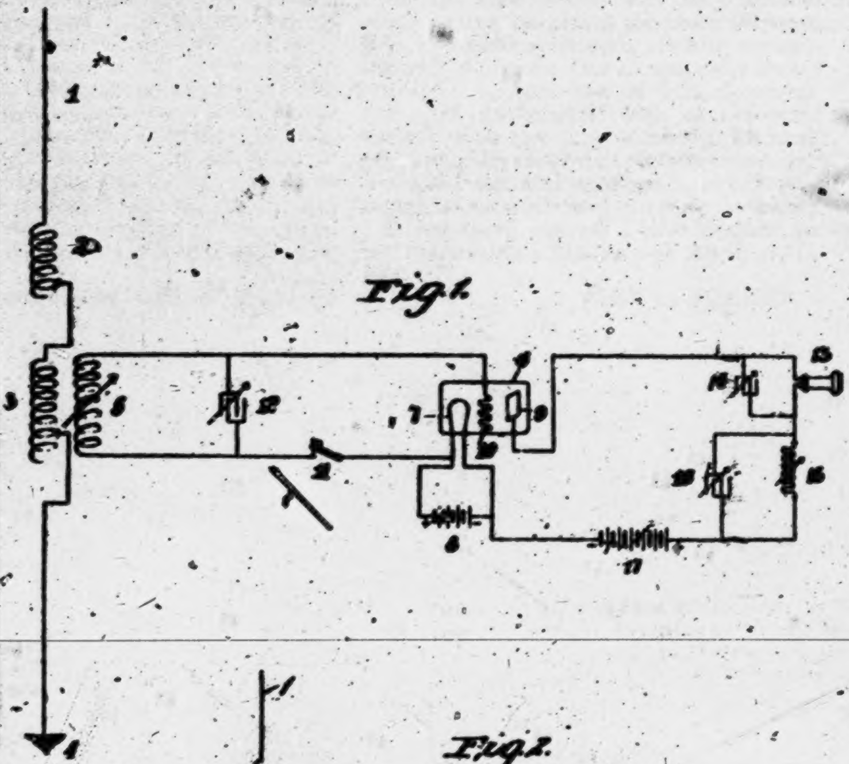
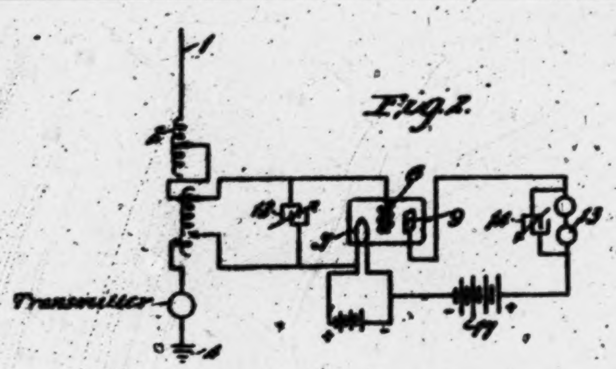


Fig. 2.



Witnesses:

Inventor: ROY A. WEAGANT

By his Attorneys, Sheffield Bentley & Betts.

UNITED STATES PATENT OFFICE.

ROY A. WEAGANT, OF ROSELLE PARK, NEW JERSEY, ASSIGNOR, BY MESNE ASSIGNMENTS, TO RADIO CORPORATION OF AMERICA, A CORPORATION OF DELAWARE.

MEANS FOR GENERATING ELECTRICAL OSCILLATIONS.

1,384,166. Specification of Letters Patent. Patented July 12, 1921.

Application filed April 9, 1914. Serial No. [illegible].

To all whom it may concern:

Be it known that I, ROY A. WEAGANT, a citizen of the United States, and a resident of Roselle Park, in the county of Union, State of New Jersey, have invented certain new and useful Improvements in Means for Generating Electrical Oscillations, of which the following is a specification.

The object of my invention is to produce means for generating electrical oscillations by means of a gaseous conducting medium which shall be small, simple and relatively cheap, shall have no moving parts, shall have reliable adjustments and be adapted to work continuously without attention.

These oscillations are capable of a variety of uses. They may be used for wireless or wire telegraphy or telephony, or any other purpose for which such oscillations may be found useful.

In the drawing accompanying this specification I have illustrated one of the many applications of my invention, the illustration being in connection with wireless telegraphy. This illustration is intended primarily to show an operative structure in which my new means of obtaining electrical oscillations are used, and is not to be understood as showing the only form or manner in which my invention may be used.

Figure 1 shows diagrammatically one embodiment of the complete system;

Fig. 2 shows a system of the same general kind in which some of the details have been varied.

Referring to the drawings and particularly to Fig. 1, these show my invention as applied to the transmitting station of a wireless telegraph system, the aerial is shown at 1, the aerial tuning inductance at 2, the primary of a transformer at 3, the aerial being earthed at 4, as usual, connected to the aerial by means of the secondary 5 of a transformer, or any equivalent means, is a circuit which includes a vessel 6. This vessel 6 may be a sealed vessel preferably of glass or similar material inclosing a plurality of conducting elements or electrodes separated by a conducting gaseous medium. Rarefied air or any other suitable medium may be used, such for instance as mercury vapor. The use of these substances involves no change in the apparatus. In the particular embodiment shown the vessel incloses a hot element 7 in the form of a filament, which is heated by any convenient source of heat such as a battery or other source of current 8, a cold element 9 in the form of a plate, and a second cold element 10, which is preferably in the form of a grid or spiral of wire. The filament is preferably formed of a substance adapted to give up a copious supply of corpuscles when heated to incandescence. The cold elements 9 and 10 may be formed of nickel or any other suitable material and are not necessarily of the particular form shown.

The terminals of the secondary 5 of the transformer are preferably connected one to the grid element 10 and the other, through a key 11, to the hot element 7. Across the terminals of secondary 5 a variable condenser 12 may be connected so that a resonant circuit may be established through the condenser and secondary 5 of the transformer.

Attached to two of the conducting elements, preferably the hot element 7 and the cold element 9, is a local circuit, which may for convenience be called the energizing circuit. A telephone or other indicating instrument 13 which is used to ascertain the correctness of the adjustments may be included in the energizing circuit. This telephone is preferably shunted by a condenser 14 which provides a convenient adjustment. In series with the telephone a relatively high variable resistance 15 may be placed, which resistance is shunted by a variable condenser 16. Although I prefer to include resistance 15 in the energizing circuit, it is not necessary to the operation of my device. In series with the resistance is a relatively powerful battery or other source of electric current 17, which furnishes the energy for the production of oscillations in vessel 6.

As thus connected, my device generates electric oscillations which are impressed upon the aerial through the inductive coupling, 3, 5 upon the closing of the key 11 thus producing signals.

In operating my device the hot member 7 is first brought to an incandescent condition. The voltage of the battery 17 is then adjusted until a high note is heard in the telephone 13, after which condenser 14, or condenser 16, or both, are varied until the note is no longer heard in the telephone. A faint blue glow is then usually observable in the vessel, which I believe to indicate that

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ionization of the gas contained therein has set in. The inductance 8 and the condenser 12 are then adjusted until the values are such as to produce the desired wave length. The aerial circuit 1, 2, 3, 4, is then adjusted until it is in tune with the oscillations being produced by the generating means. The signals are produced by opening and closing key 11 or in any other well known manner, after the proper adjustments of the generating means have been obtained.

An important advantage of my device consists in the fact that in its operation a very small variation of the current passing through the hot element 7 creates a large variation of the current delivered to the aerial. In a similar manner a small potential variation between the plate element 9 and the hot element 7 also causes a very large variation of the current delivered to the aerial. Thus, these large currents are made subject to the control of very small quantities, which may easily be controlled by apparatus unable to control large quantities of current or voltage as, for instance, a telephone or similar device.

It is obvious that the specific arrangement illustrated, wherein my improved means for generating electrical oscillations is used, may be varied in a number of ways without departing from the spirit of my invention. For instance, when used for wireless telegraphy, an auto-transformer may be used instead of an inductive coupling, or other connections to the aerial may be made use of. Also, instead of using the key 11 a continuous emission of waves may be produced and their wave lengths varied by varying the inductance of the aerial in order to produce a signal. When used in wire telegraphy or telephony, any desired wire circuit may be substituted for the aerial, and when used in wireless, or wire, telephony a telephone transmitter and receiver may be introduced in one of the circuits at a convenient point. Examples of such modifications are illustrated in Fig. 2, which shows the circuits adapted to be used either for receiving or transmitting in a wireless telephone system. I have not described the exact method of making all of these modifications and applications of my device and the many others which might be made, since they can be readily made in manners which will be understood by those skilled in the art.

What I claim is:

1. An oscillation generator system including a sealed evacuated vessel in which oscillations are generated, said vessel inclosing three electrodes, means for maintaining current through one of said electrodes, two circuits exterior to said vessel and connected each between two of said electrodes, one of said circuits containing an electrode not in the other circuit and including a source of continuous current causing the production of oscillations in said vessel, and one of said circuits containing sufficient ohmic resistance to materially and favorably affect the production of oscillations.

2. Means for generating electrical oscillations comprising an oscillation generating circuit, an energizing circuit comprising a battery and a non-inductive resistance, and means for adjusting said resistance, the said circuits being connected through a sealed vessel inclosing a plurality of elements separated by a conducting gaseous medium.

3. Means for generating electrical oscillations comprising an oscillation generating circuit, an energizing circuit containing a source of energy in series with a non-inductive resistance, associated with the generating circuits through a sealed vessel inclosing a plurality of elements separated by a conducting gaseous medium, and variable means in said energizing circuit for controlling the flow of current therein.

4. An oscillation generator system including a vacuum valve having a plate, grid and filament elements, and circuit connections therefor, and a non-inductive resistance connected between the filament and one of the other elements, and an output circuit for the generated oscillations.

5. Means for generating electrical oscillations comprising an oscillation generating circuit tuned to the periodicity of the oscillations it is desired to generate, an energizing circuit containing a source of energy in series with a non-inductive resistance shunted by a condenser, associated with the generating circuit through a sealed vessel inclosing a plurality of elements, and variable means in said energizing circuit for controlling the rate of flow of the current therein.

6. In an oscillation generator system, the combination with a normally oscillating audion having three terminal elements and a non-inductive resistance connected between two of the elements of the audion.

7. In an oscillation generator system, the combination with a normally oscillating audion having three electrode members and a non-inductive resistance connected between two of the electrode members.

In testimony whereof I have hereunto signed my name in the presence of two witnesses this 8th day of April, 1914.

ROY A. WEAGANT.

Witnesses:
WALTER S. JONES,
WM. M. EARL.

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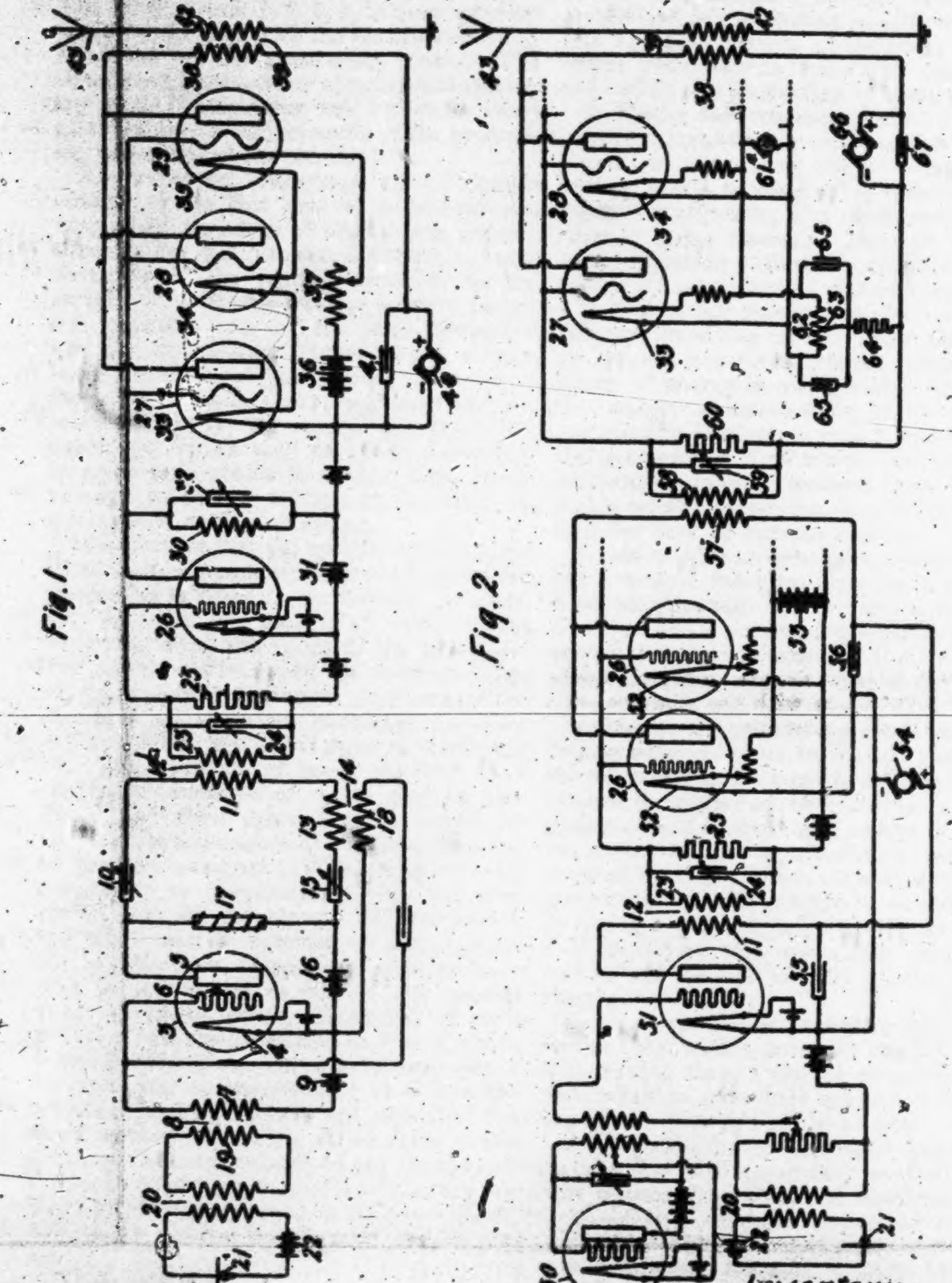
E. H. COLPITTS AND H. DE F. ARNOLD.
TRANSMISSION OF INTELLIGENCE.
APPLICATION FILED SEPT 3, 1915. RENEWED JAN. 13, 1921.

1,388,450. Patented Aug. 23, 1921.



Witnesses:
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Inventors:
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Harold D. Arnold
by S. C. Yeaner. Atty.

UNITED STATES PATENT OFFICE.

EDWIN H. COLPITTS, OF EAST ORANGE, AND HAROLD DE FOREST ARNOLD, OF MAPLEWOOD, NEW JERSEY, ASSIGNORS, BY MESNE ASSIGNMENTS, TO WESTERN ELECTRIC COMPANY, INCORPORATED, A CORPORATION OF NEW YORK.

TRANSMISSION OF INTELLIGENCE.

1,388,450. Specification of Letters Patent. Patented Aug. 23, 1921.

Application filed September 2, 1915, Serial No. 48,739. Renewed January 13, 1921. Serial No. 437,133.

To all whom it may concern:

Be it known that we, EDWIN H. COLPITTS and HAROLD DE FOREST ARNOLD, citizens of the United States, residing respectively at East Orange, in the county of Essex and State of New Jersey, and Maplewood, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in the Transmission of Intelligence, of which the following is a full, clear, concise, and exact description.

This invention relates to the transmission of intelligence, and more particularly to systems in which sustained oscillations of high frequency are employed as carrier waves, and in which the amplitude of such oscillations is made to vary in accordance with variations in message waves of comparatively low frequency.

Its object is the production of high frequency waves which are are accurately modulated in accordance with the message wave and of sufficient power for effective long distance communication.

To these ends the invention provides for the generation of carrier waves of the required high frequency, but of a power value comparable with that of the message impulses, as distinguished from that ultimately required for effective transmission. It further provides for modulating or changing the amplitude of these oscillations of low power in accordance with the form of the message wave and for amplifying the power value of the modulated high frequency oscillations to a degree sufficient for long range communication.

The arrangement of this invention makes it possible to use, as the low frequency message source, a telephone transmitter or other device capable of handling only a small amount of energy, whereas in previous systems it has been assumed that for effective long range communication it was essential that the low frequency-message source should be one capable of handling an amount of power comparable with that necessary for radiation.

In other words, the power value of the generated oscillations is chosen with reference to the power delivered by the primary modulating source rather than with reference to the amount of power necessary for radiation.

The invention will be more clearly understood by reference to the accompanying drawing, in which Figure 1 represents the system of this invention arranged for radiotelephonic transmission; and Fig. 2 shows an improvement on the system of Fig. 1, incorporating certain specific modifications which are the inventions of others and which have been made the subject matter of other patent applications.

Referring to Fig. 1, 3 is a thermionic amplifier of the well known type, having a filamentary cathode 4, an anode 5, and a grid or input electrode 6. The input circuit of this amplifier includes the cathode 4, the electrode 6, secondary winding 7 of transformer 8, and battery 9 whose function it is to give the electrode 6 a negative potential with respect to cathode 4. The output circuit of the amplifier 3 includes the anode 5, condenser 10, primary winding 11 of transformer 12, winding 13 of transformer 14, condenser 15, battery 16 and the cathode 4. An impedance coil 17 is inserted, as shown, to provide a direct current path for space current supplied to the amplifier 3 by the battery 16.

Secondary winding 18 of transformer 14 is bridged across the cathode 4 and electrode 6, as shown, and serves to feed back, into the input circuit of the amplifier, currents generated in the output circuit, thereby causing the amplifier 3 to function as a generator of high frequency oscillations, the periodicity of which is determined by the adjustment of condensers 10 and 15. For a more complete understanding of this action, reference may be had to the Colpitts Patent 1,137,384.

Primary winding 19 of transformer 8 is connected through another transformer 20 to a source of low frequency impulses, which in this case comprises a telephone transmitter 21 and a battery 22. By this arrangement the telephonic electromotive forces, generated by transmitter 21 in the winding 7, serve to vary the amplitude of the high frequency oscillations produced by the amplifier 3, and cause to be impressed on the transformer 12 a modulated high frequency wave whose envelop will have the form of the telephonic wave impressed.

The secondary 23 of transformer 12 combines with condenser 24 to form a resonant circuit which is tuned to the frequency of the high frequency carrier waves generated by amplifier 3. Bridged across the terminals of condenser 24 is a resistance 25 of several thousand ohms. This resistance serves as a load of constant impedance on the transformer 12 and has the effect of steadying the action of the system. The resistance 25, in parallel with the condenser 24 and the winding 23, is included in the input circuit of an amplifier 26, also of the thermionic type.

Amplifier 26 serves in the well known manner to amplify the power value of the modulated high frequency oscillations produced by the amplifier 3. In this case, this power amplification is directed mainly to increasing the voltage of the modulated high frequency to the degree necessary for controlling the input circuits of the high current amplifiers 27, 28 and 29.

The features of design, whereby a thermionic amplifier of the type in question may be made to produce either a voltage amplification or a current amplification, are discussed in the Arnold Patent No. 1,129,942 of March 2, 1915, and the Arnold Patent 1,329,283 of January 27, 1920.

The output circuit of amplifier 26 includes the inductance 30 for providing a direct current path for the space current delivered to the amplifier 26 by battery 31. In multiple with the inductance 30 is a condenser 32 which forms with it an anti-resonant circuit tuned to the frequency of the high frequency oscillations, and consequently of high impedance thereto.

The input circuits of the current amplifiers 27, 28 and 29 are bridged in multiple across the terminals of condenser 32. This and also other arrangements for producing the same result are disclosed in the Arnold Patents, 1,129,942 and 1,129,943 of March 2, 1915. In the present case, the cathodes 33, 34 and 35 are connected in series with a battery 36 and an adjustable resistance 37, and are heated to the required degree of incandescence by current supplied from this battery.

The common output circuit of the amplifiers 27, 28 and 29 includes winding 38 of the output transformer 39 and a source of direct current, which, in this case, is shown as a direct current generator 40, though it is obvious that any other source of direct current may be employed. A condenser 41 is preferably shunted about the terminals of the generator 40 in order to furnish a low impedance path for the high-frequency currents.

The secondary winding 42 of the transformer 39 is connected in series with the antenna 43, and serves to impress thereon high-frequency currents of large power value modulated in accordance with the telephonic wave generated by transmitter 21.

The amplifiers 27, 28 and 29 are preferably of the high current type described in the Arnold Patent No. 1,129,942 and in Arnold's application, Serial No. 277,578, filed February 17, 1919, and while, for the sake of illustration, only three of these amplifiers are herein shown, it has been found in practice that any number of such amplifiers may be connected in multiple, depending upon the amount of power required, and that two or three hundred of such amplifiers connected in multiple produce a power amplification sufficient for effective long range communication.

In the development of the system of Fig. 1, which is illustrated in Fig. 2, a slightly different method for modulating the high frequency oscillations is employed. In this case, the high frequency oscillations are generated in a separate thermionic amplifier 50, whose operation will be found described in patent to Hartley 1,356,763, patented October 26, 1920, and which is designed to generate sustained oscillations of a frequency sufficiently high for radiation from an antenna but of a power value comparable with that developed by the transmitter 21. These high frequency oscillations, together with the oscillations of telephonic frequency, are impressed upon the input circuit of an amplifier 51 and serve to produce in the output circuit of this amplifier a modulated high frequency wave similar to that developed by the amplifier 3, as described and claimed in the patent to Van der Bijl 1,350,752, patented August 24, 1920. These modulated high frequency oscillations are subjected to a voltage amplification by means of a plurality of amplifiers of the type of 26, whose filaments 52 are heated in multiple from a common direct current source 53.

The space current for both the amplifier 51 and the amplifiers 26 is supplied from a direct current generator 54, preferably shunted in each case by condensers 55 and 56 of about 1 microfarad capacity each. In this case the output circuit of the voltage amplifiers 26 is coupled by the winding 57 to the resonant circuit made up of the winding 58 and condenser 59. Condenser 59 is shunted by a high resistance 60 and is included in the input circuit of the power amplifiers 27, 28, etc.

It has been found feasible to heat the filaments 33, 34, etc., from an alternating current source, and, as shown in Fig. 2, the filaments 33, 34, etc., are heated from a 60 cycle generator 61. Where an alternating current source is employed for this purpose, the filament circuit should be shunted by an inductance 62, the middle point 63 of which is connected to the output circuit through a

resistance 64. Each half of the inductance 62 is shunted by a condenser 65.

In a practical employment of the system herein described in which effective long range communication has been obtained, six voltage amplifiers of the type of 26 were employed, and were supplied with space current from a generator 54 of 500 volts output. 250 of the amplifiers of the type of 27 and 28 were employed, and were supplied with space current from a direct current generator 66 shunted by a condenser 67 of 100 microfarads capacity and delivering space current at a voltage of 600. The filament circuit was supplied by a 60 cycle generator 61 delivering current at a voltage of 10 volts. The inductance 62 was given a value of .4 milli-henry and the condensers 65 each had a capacity of 100 microfarads.

Although this invention has been described in connection with radio signaling, it is also applicable to selective transmission of any kind and to high frequency transmission over conducting circuits as well as to radio transmission.

What is claimed is:

1. The method of signaling which consists in modulating carrier waves of insufficient power for transmission to a distant station and in increasing the power of said modulated waves before they are transmitted.

2. The method which consists in modulating, in accordance with other waves, carrier waves of insufficient power for transmission to a distant station and in increasing the power of said modulated waves before they are transmitted.

3. The method which consists in modulating, in accordance with electric current waves, carrier waves of insufficient power for transmission to a distant station and in increasing the power of said modulated waves before they are transmitted.

4. The method which consists in modulating, in accordance with signal currents, carrier waves of insufficient power for transmission to a distant station and in increasing the power of said modulated waves before they are transmitted.

5. The method of signaling which consists in generating carrier waves, supplying message impulses of a power value comparable to that of said waves, modulating said waves in accordance with said impulses and in amplifying the power value of the modulated waves to a degree sufficient for long distance transmission.

6. In a signaling system, the combination of means for supplying modulated carrier waves, a conductor adapted to transmit said waves, and an amplifier between said means and said conductor whereby said waves are amplified before they are sent to a distance.

7. In a signaling system, the combination of means for supplying modulated carrier waves, a conductor adapted to transmit said waves, and a vacuum tube of the audion type between said means and said conductor whereby said waves are amplified before they are sent to a distance.

8. In a signaling system, the combination of means for supplying modulated carrier waves, a conductor adapted to transmit said waves, and a plurality of vacuum tubes of different types connected in tandem between said means and said conductor.

9. The method of controlling the emission of high power, high frequency waves by means of feeble signal waves which consists in generating feeble high frequency oscillations, modulating said oscillations in their feeble state by means of said feeble signals, and amplifying said feeble modulated oscillations to the high power state in which they are to be transmitted.

10. The method of controlling the emission of high power, high frequency waves by means of feeble signal waves which consists in generating feeble high frequency oscillations, modulating said oscillations in their feeble state by means of said feeble signals, and separately amplifying the voltage and amperage of said feeble modulated oscillations.

11. The method of controlling the emission of high power, high frequency waves by means of feeble signal waves which consists in generating feeble high frequency oscillations, modulating said oscillations in their feeble state by means of said feeble signals, amplifying the voltage, and subsequently amplifying the amperage of the modulated oscillations.

12. The method of controlling the emission of high power, high frequency waves by means of feeble signal waves which consists in generating feeble high frequency oscillations, modulating said oscillations in their feeble state by means of said feeble signals, amplifying said feeble modulated oscillations into modulated oscillations having a relatively high voltage, and in amplifying said high voltage modulated oscillations into modulated oscillations having both a relatively high voltage and a relatively high amperage.

13. The method of controlling the emission of high power, high frequency waves by means of feeble signal waves which consists in generating feeble high-frequency oscillations, modulating said oscillations in their feeble state by means of said feeble signals, and causing said modulated oscillations to vary the potential across the input circuit of a system of thermionic amplifiers having a large power output.

14. The method of radio transmission which comprises modulating a carrier wave

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of insufficient power for transmission to a distant station, increasing the power of said modulated wave before transmission, and radiating the energy of said increased power wave.

15. The method of radio telephony which comprises modulating a carrier wave in accordance with speech waves, increasing the power of said modulated carrier wave before transmission, and radiating said wave of increased power.

16. A transmission system comprising means for supplying carrier waves of insufficient power for transmission to a distant station, means for modulating said waves, and means for increasing the power of said modulated waves before transmission.

17. A signal system comprising a source of carrier waves, means for modulating said waves in accordance with signals, a carrier wave transmission conductor, and means connecting said modulating means and said conductor for increasing the power of said modulated waves.

18. The method of transmitting signals through space which consists in generating oscillations of radio frequency having a power value comparable with that of the signal impulses to be transmitted, impressing said oscillations together with said impulses on the input circuit of a thermionic repeater, whereby modulated high frequency oscillations are produced in the output circuit of said repeater, and causing said modulated oscillations to vary the potential across the input circuit of a system of thermionic amplifiers having a large power output.

19. In a signaling system, the combination of means for supplying carrier waves modulated in accordance with signal currents, a conductor adapted to transmit said waves, and an amplifier between said means and said conductor whereby said waves are amplified before they are sent to a distance.

20. In a signaling system, the combination of means for supplying carrier waves modulated by other waves, a conductor adapted to transmit said waves, and an amplifier between said means and said conductor whereby said waves are amplified before they are sent to a distance.

21. The combination with means for generating high frequency oscillations and for modulating said oscillations in accordance with low frequency impulses to be transmitted, of a plurality of current amplifiers arranged in multiple, and a voltage amplifier energized by said means and working into said current amplifiers, whereby the power of said modulated oscillations is increased.

22. The combination with means for generating high frequency oscillations and for modulating said oscillations in accordance with low frequency impulses to be transmitted, of a plurality of thermionic amplifiers arranged in multiple having a common input circuit, and a thermionic amplifier adapted to be energized by said means and working into said input circuit, whereby the power of said modulated oscillations is increased.

23. The combination with means for generating high frequency oscillations and for modulating said oscillations in accordance with low frequency impulses to be transmitted, of a plurality of thermionic current-amplifiers arranged in multiple having a common input circuit and a common output circuit, a thermionic voltage-amplifier associated with said means and working into said input circuit, whereby the power of said modulated oscillations is increased and an antenna circuit coupled with said output circuit.

24. The combination with a thermionic amplifier having an input circuit and an output circuit, of means for impressing a high frequency electromotive force on said input circuit, other means for impressing on said input circuit a low frequency electromotive force of an amplitude comparable with that of said high frequency electromotive force, whereby the amplitude of the oscillations produced in said output circuit is relatively small and is made to vary in accordance with the variations in said low frequency electromotive force, and means connected with said output circuit for amplifying said high frequency oscillations to the high power state in which they are to be transmitted.

25. In a system for radio transmission, the combination with a thermionic amplifier having an input circuit and an output circuit, of means for impressing an audio frequency electromotive force and a radio frequency electromotive force of comparable and feeble intensities on said input circuit whereby a low power modulated high frequency current is produced in said output circuit, and means for amplifying said modulated current to a high power state in which it is to be transmitted.

26. In a system for radio transmission, the combination with a thermionic repeater having an input circuit and an output circuit, of means for impressing an audio frequency electromotive force and a radio frequency electromotive force of comparable magnitudes on said input circuit whereby a modulated high frequency current is produced in said output circuit, and a plurality of thermionic repeaters coupled with said output circuit for amplifying said modulated high frequency currents to a high power value.

27. The method of carrier current telephony which includes generating speech waves and carrier current waves of comparable magnitude, impressing all of said waves upon a modulator, amplifying the modulated carrier waves and transmitting them to a distant station, said carrier waves before amplification being too feeble for transmission and reception at said station.

28. The method of high frequency transmission which includes generating low frequency modulating waves and carrier current waves of comparable magnitude, impressing all of said waves upon a modulator, amplifying the modulated carrier waves and transmitting them to a distant station, said carrier waves before amplification being too feeble for transmission and reception at said station.

In witness whereof, we hereunto subscribe our names this 31st day of August, A. D. 1915.

EDWIN H. COLPITTS.
HAROLD DE FOREST ARNOLD.

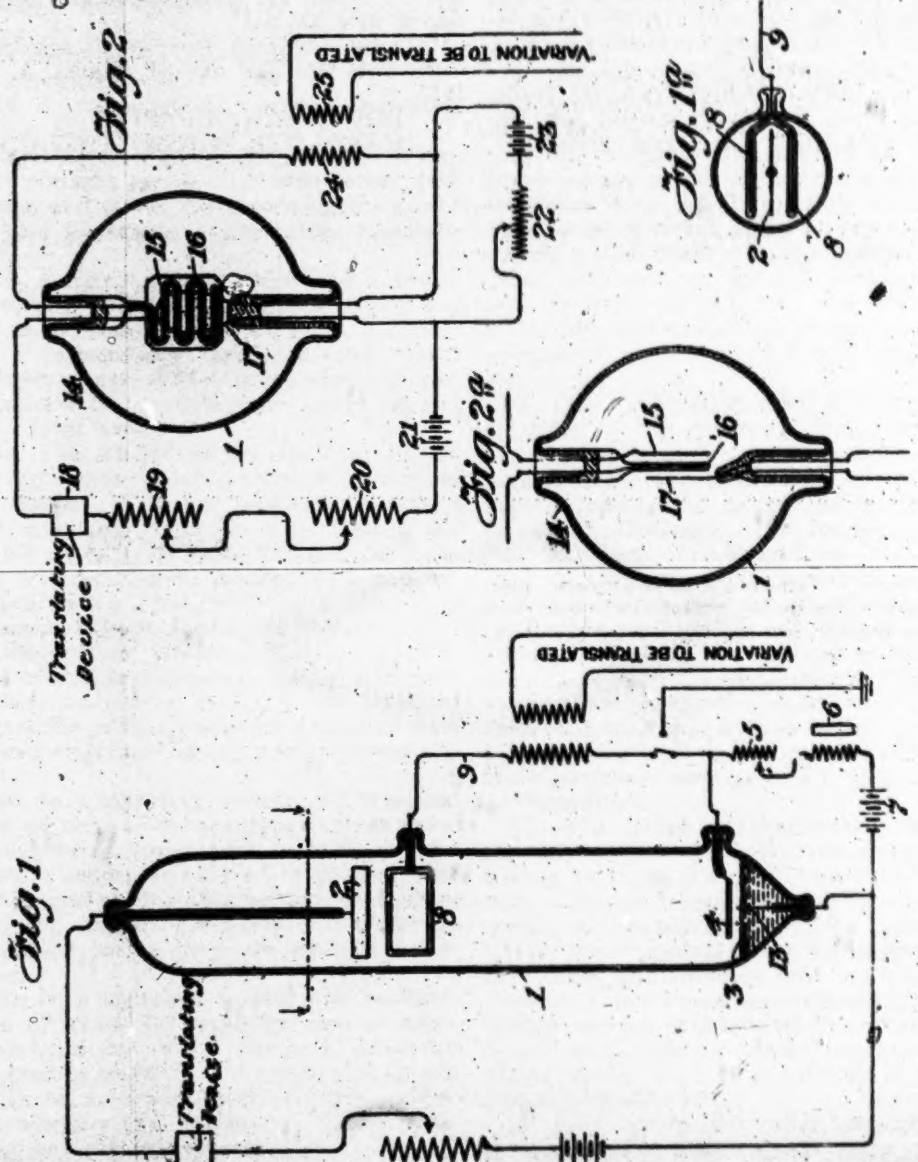
1537

P. C. HEWITT.

APPARATUS FOR TRANSLATING ELECTRICAL VARIATIONS.

APPLICATION FILED MAR. 12, 1915.

1,393,369. Patented Oct. 11, 1921.



WITNESSES

Chas. J. Clagett

Wm. H. Capel

Peter Cooper Hewitt INVENTOR

BY

ATTORNEYS

UNITED STATES PATENT OFFICE.

PETER COOPER HEWITT, OF RINGWOOD MANOR, NEW JERSEY.

APPARATUS FOR TRANSLATING ELECTRICAL VARIATIONS.

1,393,369. Specification of Letters Patent. Patented Oct. 11, 1921.

Application filed March 12, 1915. Serial No. 13,873.

To all whom it may concern:

Be it known that I, PETER COOPER HEWITT, a citizen of the United States, and resident of Ringwood Manor, county of Passaic, State of New Jersey, have invented certain new and useful Improvements in Apparatus for Translating Electrical Variations, of which the following is a specification.

My invention relates to means for controlling one circuit by another and is serviceable for affecting a circuit by potential variations in another circuit, insulated from it, even though the currents are alternating currents of very high frequency.

The invention consists of a vacuum, gas or vapor tube consisting of a positive electrode, a negative electrode capable of receiving positive current and of a conductor inside the tube, hereafter called the potential terminal, insulated from the gas or vapor path in the same manner as if it were entirely covered by a coating of insulating material whereby it affects the path between the main electrodes by its potential charge and not by current passing from it to the path by conduction.

It is useful as a receiver for wireless telegraphy and telephony and for transferring telephone currents from one circuit to another and for amplifying and relaying such currents and will serve to translate rapidly varying currents of high frequency, and translate variations of energy.

My invention is best explained by a concrete device, as shown in the drawing, and by a setting forth of the action of said device.

In the drawings, Figure 1 represents a device embodying my invention as connected in circuit. Fig. 1ᵃ is a detail. Figs. 2 and 2ᵃ illustrate a modified form.

In Fig. 1, is shown a vacuum tube, 1, having a positive electrode, 2, a negative electrode, 3, and a keep alive, 4, and a circuit connecting 3 and 4 consisting of resistance, 5, inductance, 6, and a storage battery, 7, for maintaining the electrode 3 in active condition.

A conductor, 8, here called potential terminal, is shown insulated from the vacuum, gas or vapor, and consisting of a material like platinum, for instance, covered by insulating material like glass, for instance, so that the conductor is prevented from carrying current to the interior of the device by true conduction, but is only capable of affecting the interior by reason of the electric charge impressed on the conductor conveyed by means of the conductor, 9, connected to it and passing through the wall of the vessel.

A circuit is connected to the positive electrode 2 consisting of resistance, 10, a battery, 11, and a translating device or indicating instrument, 12, with leads connecting the same to negative electrode 3 or, if preferred, to electrode 4. Current is first caused to pass between auxiliary positive electrode 4 and negative electrode 3 in a desired quantity, say, from ½ to three and one-half amperes, by suitably adjusting the various parts of the circuit 5, 6, 7; it being of advantage that the inductance 6 be large. The negative electrode 3 is stabilized, in case a liquid electrode is used, such as mercury, by a projection, 13, such as platinum or tungsten.

The circuit to the positive electrode 2 is adjusted to pass the desired current by means of the resistance 10, battery 11, and the translating device 12. The current in this circuit is selected according to requirements and may be very small if the device is required to translate very minute variations of energy, as very small potential variations impressed on the potential terminal or conductor 8 will not affect currents of over a certain magnitude, with sufficient force to yield practical results.

The potential variations or energy variations to be translated are applied by means of conductor 9 to the potential terminal, and these variations affect the current flow in the tube circuit, including the indicator, from the positive electrode 2.

The device is sensitive to potential variations applied to potential terminal 8. If the device is used for energy variations of low potential, in order that it may be most sensitive to such variations, the potential of the energy variations should be raised to the highest possible potential at the potential terminal by any of the well known expedients to raise the potential of variations. As there is no current flow from potential terminal, 8, the necessary raising of potential may be brought about with an exceedingly small amount of energy to be translated. One terminal of such a device should be connected at 9, and the other side of the circuit to any of the other leads entering the device, or may be connected to ground or the capacity of the circuit may be sufficient.

Instead of a plate as shown as the potential terminal at 8, Fig. 1, a perforate terminal such as a grid of insulated wire may be used and may be turned in a horizontal position instead of vertical as shown at 8, in Fig. 1. One form of such grid is shown at 16, in Fig. 2. The perforate terminal or the wire forming the grid may be covered with a coating of glass, preferably thin, or other suitable insulating material.

In place of a mercury electrode maintained in a broken down state by current flow from an auxiliary positive electrode and independent source of current, an incandescent body may be used as the electrode, such as the filament of an incandescent lamp, which may be maintained hot by an independent circuit.

Fig. 2 comprises a device wherein a filament, 17, serves as a negative. The filament 17 is included in a separate circuit consisting of a battery, 23, and a variable resistance 22 for maintaining it incandescent so that it may act as a negative to receive positive current.

Variations are applied by means of primary coil, 25, acting on secondary coil, 24, which serves as a potential raising device; one terminal of 24 is connected to the potential grid 16; the other terminal is connected to the filament circuit. The positive electrode, 15, is connected to the indicating instrument, 18, included in a circuit having inductance, 19, resistance, 20, battery, 21, and connected to the negative electrode terminal, the circuit being completed by means of the path between the electrodes 15 and 17, inside the device. The potential impressed on the potential electrode 16 varies the current flow in the circuit 15, 18, 19, 20, 21, and 17.

Any suitable translating device or indicating instrument, such as the primary of a transformer, the secondary of which may be utilized for any desired purpose, or a telephone receiver, or a relaying apparatus, may be used at 12 or 18 in Figs. 1 and 2.

The device is also useful when alternating currents are applied to the main electrodes instead of direct current here illustrated, in which case the device will rectify the current and pass direct current impulses.

With very high frequency currents the device is very useful.

I claim as my invention:

1. In an apparatus for translating electrical variations, an electric device having a potential terminal located therein and completely covered with insulating material, said insulated potential terminal being separately mounted in said device.

2. In an apparatus for translating electrical variations, a container, electrodes therein separated by a vacuum, gas or vapor space, and a conductor within the container covered throughout with insulating material.

3. In a vacuum, gas or vapor apparatus, a container having electrodes and a potential terminal within the container covered throughout with insulating material, said internal potential terminal being in operative relation to the electrodes and spaced apart therefrom, and means for impressing electrical variations upon said internal potential terminal.

4. In an electric apparatus, a container having electrodes therein separated by a vacuum, gas or vapor space, and a conductor within the container covered throughout with insulating material, and means for impressing electrical variations upon said internal conductor.

5. In an electric apparatus, a container having positive and negative electrodes therein separated by a vacuum, gas or vapor space, means for passing current between said electrodes, and a conductor within the container covered throughout with insulating material in operative relation to the current path between the electrodes, and means for impressing electrical variations on said internal conductor.

6. The combination in a vacuum, gas or vapor device, of two electrodes having a current path between them and a conductor within the device interposed between the two electrodes and insulated from the current path.

7. A vacuum, gas or vapor device, having two electrodes and a current path between them and a conductor within the device interposed between the two electrodes and insulated from the current path, in combination with a source of electrical variations connected with the insulated conductor, a receiving circuit, and a translating device therein.

8. In a vacuum, gas or vapor device, two electrodes having a current path between them, a conductor within the device interposed between them and insulated from the current path, in combination with means for raising the electrical energy applied to the insulated conductor to the highest practical potential.

9. A vacuum, gas or vapor device having positive and negative electrodes, a conductor within the device spaced apart from said electrodes and insulated from the vacuum, gas or vapor path between the positive and negative electrodes in combination with means for impressing potential variations on the insulated conductor, a circuit including one of the main electrodes of the device, and a translating device responsive to currents therein.

10. In a vacuum, gas or vapor device, two electrodes having a current path between them, a conductor within the device inter-

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posed between the two electrodes and insulated from the current path, in combination with a source of electrical variation acting on the insulated conductor, and means for raising the potential of the said variations.

11. The combination with an exhausted container, electrodes therein having a vacuum, gas or vapor current path between them, of a body of conducting material within the container spaced apart from said electrodes and insulated from the current path, and means for making electrical connection with the insulated conductor through the walls of the container.

12. The combination with an inclosing chamber, 1, a positive electrode, 2, a negative electrode, 3, and a potential terminal within the chamber spaced apart from said electrodes and insulated from discharges passing between the said electrodes.

13. In an apparatus for amplifying electrical variations, an electric device having electrodes, means for passing electric current between said electrodes, a body of conducting material within said device interposed in the path between the electrodes and insulated from said path.

14. An amplifier for electrical variations, comprising an evacuated container, a positive and a negative electrode, means for passing electric currents between the same, an insulated potential terminal within said container and spaced apart from said electrodes and receiving electrical charges corresponding to the variations to be amplified and affecting the current path but insulated therefrom.

Signed at New York, in the county of New York and State of New York, this 11th day of March, A. D. 1915.

PETER COOPER HEWITT.

Witnesses:

WALTER E. F. BRADLEY,

HAROLD B. WOODWARD.

1541

H. DE F. ARNOLD.
THERMIONIC AMPLIFIER.
APPLICATION FILED JAN. 8, 1920.

1,398,665. Patented Nov. 29, 1921.

Fig. 1

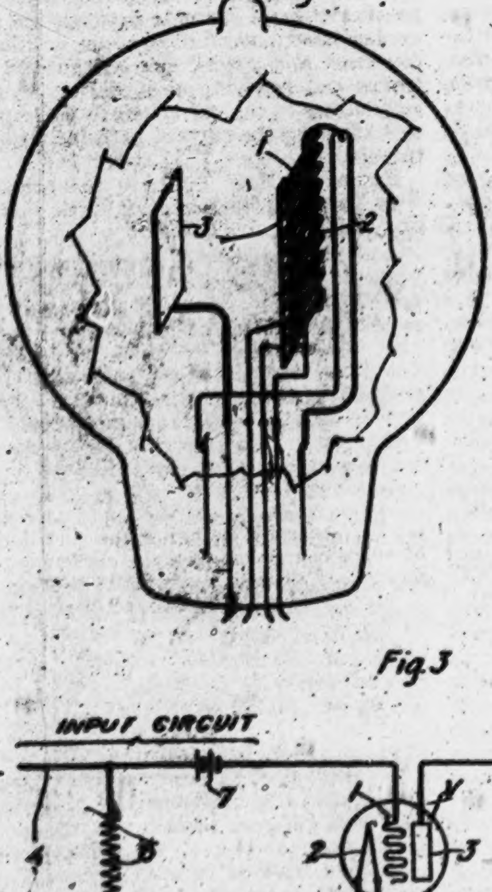


Fig. 2

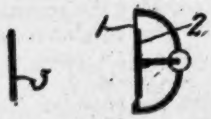
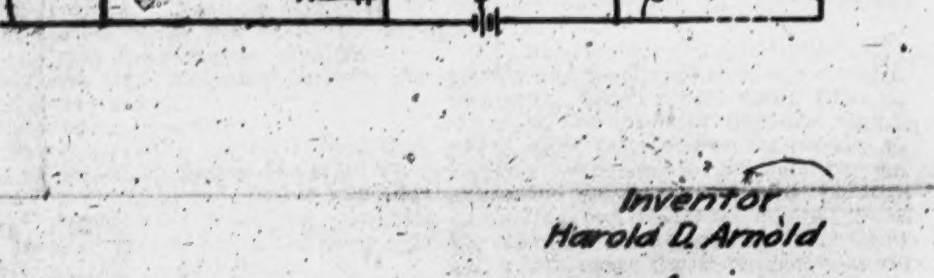


Fig. 3



Inventor
Harold D. Arnold
by C. C. Sprague Att'y.

UNITED STATES PATENT OFFICE.

HAROLD D. ARNOLD, OF MAPLEWOOD, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

THERMIONIC AMPLIFIER.

1,398,665. Specification of Letters Patent. Patented Nov. 29, 1921.

Original application filed July 30, 1918, Serial No. 247,422. Patent No. 1,329,283, dated January 27, 1920. Divided and this application filed January 8, 1920. Serial No. 350,157.

To all whom it may concern:

Be it known that I, HAROLD DE FOREST ARNOLD, a citizen of the United States, residing at Maplewood, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Thermionic Amplifiers, of which the following is a full, clear, concise, and exact description.

This invention relates to thermionic amplifiers of the electric discharge type and more particularly to those of the three element type, preferably highly evacuated, and its object is to provide a structure by which certain desired characteristics of the amplifier may be secured at will and in an efficient manner. This object is accomplished by proportioning the geometrical and electrical relations of the various elements of the device in a manner more fully explained later in this specification.

In order that the novelty of this invention may be appreciated, and that those skilled in the art may be enabled to use this invention to best advantage, it is necessary that certain terms hereinafter used shall be defined. The following brief discussion is intended to explain the operation of the device and to define the terms to be employed.

The thermionic amplifier consists of a container preferably although not necessarily highly evacuated and including a hot electron-emitting cathode, such as the so-called "Wehnelt" cathode, an anode and an auxiliary electrode called the grid, which is usually, though not always located between the anode and the cathode. A battery is connected so as to force the electrons liberated at the cathode toward the anode, thus setting up a convection current carried by electrons in the evacuated space. In this specification since only the structure of the device itself is under discussion, only the effects of changes in that structure are considered. Obviously a change in the battery will also change the characteristics of the circuit, but in a way which is already known in the art. Due to the presence of these electrons, a negative space charge is established between the anode and the cathode, whose effect is to limit the number of electrons which can leave the cathode, and consequently to limit also the current which can flow in the output circuit, by which is meant the circuit including the battery and the path of the space current. The object of the grid is to furnish a means for introducing a further negative charge into the space between the anode and the cathode, or for introducing into it a positive charge which shall neutralize the effect of part of the space charge due to the electrons. In the first case, the convection current is decreased; in the second it is increased. In order to force this charge to the grid, a source of electromotive force is connected between grid and cathode, that is, between the input terminals of the device. The effect of such an impressed electromotive force is therefore to alter the magnitude of the space current in the amplifier by changing the distribution of space charge between the electrodes, and moreover this is accomplished without requiring that the impressed electromotive force shall do more work than that involved in forcing the charge to the grid against the counter voltage of the condenser formed by grid and filament. Since in this operation the change in power consumed in the output circuit may be much greater than that required in charging the condenser, the device acts as an amplifier. This variation in space current, due to an impressed electromotive force, will hereafter be called the output current of the amplifier and the variation in voltage, which appears in the output circuit due to the impressed electromotive force, will be called the output voltage. The reason for adopting these definitions is that in the practical applications of the amplifier it is only these variations in current or voltage which are utilized; in fact, a transformer is ordinarily used to derive power from the output circuit, and obviously the steady space current or the steady output voltage have no effect in the secondary of that transformer and may be ignored for practical purposes. Thus, the term voltage amplification means here the ratio of the alternating voltage appearing in the secondary of such a unity ratio transformer to the alternating voltage impressed across the filament and grid, when the transformer primary is made to include the whole of the output circuit external to the am-

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plifier. In simpler terms, it is the ratio of the above defined output voltage to the impressed input voltage.

There will also be occasion to consider the ratio of output current to input voltage, the latter being taken as standard throughout. When this ratio is high, other things being the same, the amplifier will be said to be of the high current type, and vice versa. This latter ratio is, of course, not a pure number, but is of the nature of an admittance.

It has been found that amplifiers may be designed for given circuit conditions so that they will have whichever of the above mentioned characteristics is desired. That is, one may be designed to deliver to a receiving device a comparatively high voltage with a low current, or vice versa. The principles of operation which have been discovered which enable this result to be accomplished may be stated as follows.

In the first place it has been found that it is of advantage to locate the grid as near the cathode as possible whatever the desired voltage amplification or output current. In practice it has been found that when the two elements are separated only by a mere oxidizing coating the most efficient action is obtained. Unless there is a solid and continuous spacing element between the two it may be necessary of course to separate them a small distance to prevent actual contact between them due to forces set up during operation. By saying that the elements are placed as close together as possible it is meant that the distance between them is made as small as possible without introducing appreciable electrical or mechanical disturbances during operation.

Again, it has been found that, when the cathode and grid are placed as near to each other as possible, decreasing the distance from the anode to the cathode decreases the voltage amplifying power of the tube without at the same time reducing the variable current set up in the output circuit. That is, if we consider two tubes, one of which has the anode and cathode widely spaced while the other has them near together, the grid being very close to the cathode in each case, the first tube when installed in a system of the usual kind, tends to cause marked voltage amplification, while the latter, if substituted for the former, increases the variable current output, and at the same time lowers the voltage amplification.

A third principle of operation of the thermionic repeater which has been discovered may be stated as follows. To increase voltage amplification decrease the ratio of open space in the grid to conducting surface, and to decrease voltage amplification or to increase the variable output current increase this ratio.

The behavior of thermionic repeaters in another very important respect has been discovered. This may be stated as a fourth principle of operation as follows: Maximum efficiency is obtained when the impedance between the anode and cathode is equal to the total impedance of the variable current consumption circuit. This total impedance includes the total line impedance and that of the receiving or translating device or devices to which power is being supplied.

It has been found that tubes may be constructed in such manner as to take advantage of any number or of all of the above mentioned principles with, of course, correspondingly increased efficiency and adaptability.

An object of the invention is to provide an audion, or equivalent system, by which a proper impedance ratio is obtained between the impedance of that portion of the output circuit which is without the audion and that of the remaining portion of the external circuit, whereby a greatly increased efficiency is obtained.

Another object of the invention is to provide an audion, or equivalent device, which will operate efficiently with a current operated translating device without the use of a voltage transformer between the audion and the translating device.

Viewed broadly, the invention provides for an increase of the efficiency of an audion, or equivalent device, by novel spacing of the electrodes and the current control element, and also an increase of efficiency, when used with a current operated translating device, by obtaining the proper ratio of the conductive surface to open space in the grid or current control element.

Other and more specific objects of the invention will be apparent from the appended claims.

The invention will be better understood by reference to the following specification taken in connection with the accompanying drawing in which—

Figure 1 represents the structure of an amplifying tube which is designed to give greater voltage amplification than those of the prior art; Fig. 2 is a plan view of the amplifier of Fig. 1 arranged to exhibit the geometrical configuration; Fig. 3 is a circuit diagram showing an amplifying system making use of an amplifier of the type shown in Fig. 1. In these figures, like numerals represent corresponding parts.

Referring to Figs. 1 and 2, 1 represents the grid element, 2 the cathode or filament and 3 the anode or plate. The plate is placed a considerable distance from the cathode, and the grid is placed very close to the cathode and may be separated therefrom only by a thin insulating film as, for

example, an oxidizing coating on one or the other of these elements. Further, the grid is made to have a fine mesh and thus to obstruct greatly the view of the plate as seen from the cathode.

Fig. 3 is a diagram of an amplifying system in which a tube V of the type shown in Fig. 1 is employed. The tube has the usual input circuit 4, and output circuit 5, 5. The exact arrangement of input and output circuits is that shown in Patent 1,129,942 to this applicant. In this patent there is shown and claimed a combination with another system of a system of the type shown in Fig. 3, such combination having marked advantages for certain purposes specified in said patent. The purpose of the present application is to specifically describe and claim a system employing novel thermionic amplifiers, these being capable of more general use than that disclosed and claimed in the above mentioned patent.

A source of potential 7 may be inserted in the input circuit to bring the grid to a desired initial or working potential. No transformer need be used, the incoming line being directly connected to the input electrodes, and the outgoing line, to the output electrodes. A high resistance element 6 may be connected across the input circuit as shown. A coil 8 of large inductance provides a path for direct current for the tube V, such current being supplied by a source B. The coil 8 will not conduct an appreciable amount of the variable current in the output circuit owing to its high impedance to such current. The condenser 9 is inserted in the line to prevent flow of direct current from the source B through the receiving device 10 if the latter does not itself prevent such flow.

The receiving device 10 may be one which operates most efficiently upon high variable voltage and low current. In accordance with the principles discussed above, the grid 1 and cathode 2 are placed very close together while the plate 3 is widely separated from the cathode, the distance between the two being that necessary to give the desired current and voltage output characteristics. It is usually necessary however for efficient operation to consider first the impedance characteristics of the tube between filament and plate and the impedance of the receiving device and line, in accordance with the fourth principle of operation stated above. The receiving device 10 is one of high impedance and accordingly the impedance of the tube between filament and plate is made high, the two impedances being made as nearly the same as possible consistent with other possible conflicting requirements. They should at least be of the same order of magnitude, for example one being 100,000 ohms and the other 25,000 ohms. The receiving device 10 may be a second amplifying tube or similar device.

By thermionic repeater is meant a repeater depending for its operation upon current discharge from a heated cathode. It is obvious, however, that the invention might be applied to a discharge device in which other means is employed for liberating electrons from the cathode. In its broadest aspect the invention is not limited to the particular structure herein illustrated, but may be found useful in modified forms or types of discharge tubes and in connection with a variety of circuit arrangements—as for example, those illustrated in Figs. 9 and 10 of the copending application of H. D. Arnold, which matured into Patent No. 1,329,283, dated Jan. 27, 1920, of which the present application is a division.

What is claimed is:

1. A thermionic discharge device having a cathode, an anode and a controlling element, said controlling element being located in close proximity to the cathode, and said anode being relatively widely spaced from said cathode whereby the device operates to repeat electrical waves and impulses with amplified voltage.

2. A thermionic discharge device having a cathode, an anode and a controlling element, said controlling element being located in close proximity to the cathode, and said anode being relatively widely spaced from said controlling element whereby the device operates to repeat electrical waves and impulses with amplified voltage.

3. The combination with a thermionic discharge device having a cathode, an anode, and an impedance varying element of an input circuit and an output circuit therefor, means for producing a variable electromotive force in said input circuit, a source of electromotive force in said output circuit, and translating means for utilizing the variable current of said output circuit, said impedance varying element being in immediate proximity to the cathode, but out of electrical contact therewith, and said cathode being widely spaced from said anode so that for the impedances and voltages employed outside the device, the device operates to amplify the voltage of energy impressed upon said input circuit.

4. The combination with a thermionic discharge device having a cathode, an anode, and a controlling element of an input circuit therefor, and an outgoing circuit having impedance and connected to said anode and cathode, said cathode, anode and controlling element being so spaced that the impedance of said discharge device between said anode and said cathode is of the same order as that of said outgoing circuit and that said device operates as a voltage amplifier.

5. The combination with a thermionic dis-

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charge device having a cathode, an anode, and an impedance varying element, of an input circuit and an output circuit therefor, an impedance element in said output circuit, means for producing a variable electromotive force in said input circuit, and a source of electromotive force in said output circuit, said cathode being as near as possible to said impedance varying element and said anode being relatively widely spaced from said cathode whereby the variable voltage across said anode and cathode in said output circuit is much greater than that in said input circuit.

6. The combination with a thermionic discharge device having a cathode, an anode, and an impedance varying element, of an input circuit and an output circuit therefor, an impedance element in said output circuit, means for producing a variable electromotive force in said input circuit, and a source of electromotive force in said output circuit, said cathode being in immediate proximity to said impedance varying element, said anode being relatively widely spaced from said cathode, and said impedance varying element being in the form of a discontinuous conductive surface, the ratio of conductive surface to open space in said impedance varying element being high, whereby the variable voltage across said anode and cathode in said output circuit is much greater than that in said input circuit.

7. A thermionic discharge device having a cathode, an anode and a controlling element, said controlling element being located in close proximity to the cathode, said anode being relatively widely spaced from said cathode, said controlling element being in the form of a discontinuous conductive surface having a high ratio of conductive surface to open space whereby the device operates to repeat electrical waves and impulses with voltage amplification.

8. Means for amplifying the voltage of electrical waves and impulses comprising an electric discharge device having a cathode, an anode, and a controlling element, said controlling element being located in close proximity to the cathode, said anode being relatively widely spaced from said cathode, an output circuit connected to said cathode and anode, a translating device to which waves of amplified voltage are delivered connected in said output circuit, the impedance of that portion of said output circuit which is within said discharge device being of the same order of magnitude as the impedance of said translating device.

9. Means for amplifying the voltage of electrical waves and impulses comprising a thermionic discharge device having an anode, a cathode, and an impedance varying element, said impedance varying element being located in close proximity to the cathode, and said anode being relatively widely spaced from said cathode, of an input circuit connected to said impedance varying element, a source of variable electromotive force in said input circuit, a source of electromotive force connected to said anode and cathode, and a work circuit non-magnetically connected to said anode and cathode, the impedance of said discharge device between said cathode and anode being of the same order as that of said work circuit.

10. Means for amplifying the voltage of electrical waves and impulses comprising an electric discharge device having an anode, a cathode, and a current control element, said current control element being located in close proximity to the cathode, and said anode being relatively widely spaced from said cathode, an input circuit for said device, a source of variable energy to be amplified connected in said input circuit, and a work circuit to which the amplified energy is delivered non-magnetically connected to said output circuit.

In witness whereof, I hereunto subscribe my name this 7th day of January, A. D. 1920.

HAROLD D. ARNOLD.

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1546

K. S. JOHNSON.

TRANSMISSION SYSTEM.

APPLICATION FILED JULY 1, 1918.

1,432,863. Patented Oct. 24, 1922.

Fig. 1.

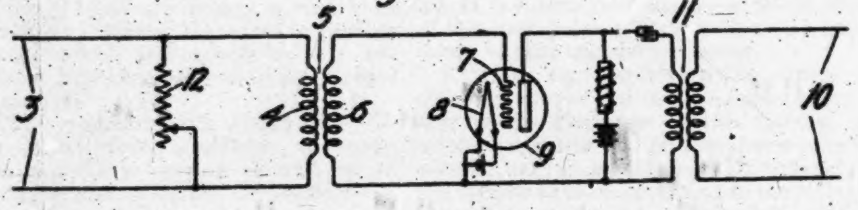
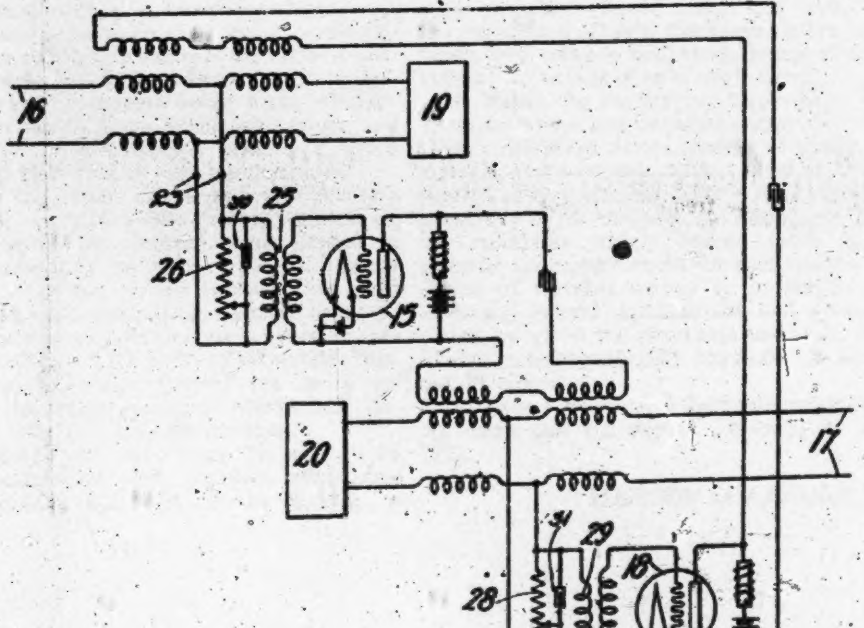


Fig. 2.



Inventor:
Kenneth S. Johnson.
by J. S. Roberts Att'y.

Patented Oct. 24, 1922. 1,432,863

UNITED STATES PATENT OFFICE.

KENNETH S. JOHNSON, OF JERSEY CITY, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

TRANSMISSION SYSTEM.

Application filed July 1, 1918. Serial No. 242,797.

To all whom it may concern:

Be it known that I, KENNETH S. JOHNSON, a citizen of the United States, residing at Jersey City, in the county of Hudson, State of New Jersey, have invented certain new and useful Improvements in Transmission Systems, of which the following is a full, clear, concise, and exact description.

This invention relates to transmission systems, more particularly it relates to means for improving the quality of transmission from an incoming line to a vacuum tube repeater.

It is well known in the art of telephony, that the proper functioning of a transmission system depends, to a great extent, on the relative proportioning of the electrical impedances of the component elements of the system. Thus it has been found that the voltage impressed by a transformer from an incoming line on a repeater varies considerably with the frequency, thereby impairing the quality. In accordance with this invention, it has been found that the quality of transmission in such a circuit may be considerably improved by shunting an impedance across the input side of the transformer. On a one-way repeater circuit the value of the impedance may be varied between considerable limits, although in general, a resistance of the order of the effective resistance of the line has been found quite satisfactory. In two-way repeater circuits where accurate balancing between the lines and the artificial networks is required, the value of the impedance across the input side of the transformers should be equal to one-half the impedance of the incoming line. That this value should hold for two way repeater circuits will be apparent from the detailed description of this invention.

Previous to this invention it has been known that the quality of transmission could be improved by connecting across the terminals of the secondary winding of the input transformer a resistance equal to the value of the effective resistance of the line multiplied by the square of the ratio of turns of the transformer, but such an arrangement necessitates the use of a very high and more costly resistance compared with that employed in this invention. For good repeater operation, it is also preferable to have as little apparatus as possible associated with the input circuit of a repeater, because of capacity effects that might result therefrom, which would cause a substantial short circuit between the input electrodes of the repeater and a lowering of its efficiency.

It has been found that there is also less energy lost in the input transformer when the resistance is on the input side and also less liability for cross-talk between neighboring repeater circuits. Experiment has furthermore shown that a greater amplification may be obtained from a repeater having the resistance across the input side rather than the output side of the transformer.

This invention will be better understood by reference to the detailed description of the drawings, in which Figure 1 shows this invention in connection with an incoming line inductively associated with a vacuum tube repeater for one-way operation, while Figure 2 shows this invention in connection with a two-way repeater circuit.

Referring to the drawing, 3 is an incoming line which terminates in the primary winding 4 of a transformer 5, the secondary 6 of which is connected between the grid 7 and cathode 8 of a vacuum tube repeater 9. Signals impressed upon the input circuit of the tube 9 by the line 3 are therefore reproduced in amplified form in the output circuit of the tube and the amplified signals may be impressed upon an outgoing line 10 by a transformer 11.

In order to prevent the voltage impressed by the transformer 5 on the amplifier 9 from varying with the frequency, it is desirable to insert a resistance 12 in shunt to the primary winding. From a quality standpoint the smaller the value of this resistance the better the quality, but it is apparent that making the resistance very small would improve the quality only at considerable expense to the transmission efficiency of the system.

In general it will be found that for transmission lines a value of the resistance 12 of the order of the effective resistance of the incoming line will be quite satisfactory.

In Figure 2, 15 is a vacuum tube for repeating signals from the line 16 to the line 17, while 18 is a vacuum tube for repeating signals in the opposite direction. 19 is an artificial network for simulating the impedance of the line 16 and should have an impedance equal to the impedance of the line.

Similarly the network 20 should simulate the impedance of the line 17. In accordance with this invention the impedance of the circuit at the point 23 should be the same looking in either direction, and since the incoming circuit for the transformer comprises in parallel the line 16 and the artificial line 19, the effective resistance at the terminals 23 looking in the direction of the incoming circuit is one-half the effective resistance of the line 16. The value of the resistance 26 should then be equal to one-half the resistance of the line 16. Similarly, resistance 28 across the primary winding 29 should equal one-half the effective resistance of line 17. With such values for resistances 26 and 28, the balance conditions necessary for no local circulation of power in the repeater station are obtained.

The resistances 26 and 28 will in some cases provide a sufficiently accurate simulation of the impedance of lines 16 and 17. In case that these lines have an appreciable amount of reactance as well as resistance, the reactance component of the impedance may be simulated by reactances such as condensers 30 and 31 in shunt to the resistances 26 and 28 respectively. The circuit or mesh provided by resistance 26 and condenser 30, and by resistance 28 and condenser 31 is commonly called a network or artificial line.

Although this invention has been described above in connection with circuits employing vacuum tube repeaters, it is evident that it is also applicable to circuits in which other types of repeaters such as mechanical repeaters are employed.

It is obvious that the principles above set forth may be embodied in systems widely different from that described herein without departing from the spirit of the invention as defined in the appended claims.

What is claimed is:

1. In combination, an incoming line, a translating device, a transformer having a primary winding connected with said line and a secondary winding connected with said device, and an impedance connected to the primary side of said transformer and having an impedance closely approximating the effective impedance of said line.

2. In combination, an incoming line, a transformer having its primary winding connected with said line, a repeater for said line connected with the secondary winding of said transformer, and a resistance element connected in shunt to the terminals of said primary winding for improving the quality of transmission from said line to said repeater, said element having a resistance closely approximating the resistance of said incoming line.

3. The combination with an incoming circuit, of a transformer having its primary connected to said line, a vacuum tube associat[ed] with the secondary winding of sai[d] transformer, and a resistance connecte[d] across the terminals of said primary, sai[d] resistance having a value closely approx[i]mating the resistance of said circuit.

4. A two-way repeater circuit comprisin[g] an actual line, an artificial line and a cir[]cuit connected between said lines compri[s]ing a transformer, an artificial line con[]nected at the primary of said transforme[r] and a repeater connected to the secondary o[f] said transformer.

5. A two-way repeating system compri[s]ing an incoming line, an outgoing line, [a] uni-directional path for repeating betwe[en] said line comprising an amplifying elemen[t,] a transformer for connecting said elemen[t] to said incoming line, and an impedan[ce] connected in shunt to the primary of sai[d] transformer, said impedance having a valu[e] closely approximating one-half of the impe[d]ance of said incoming line.

6. A two-way repeater circuit compri[s]ing two lines, a vacuum tube for repeatin[g] signals from one of said lines to the othe[r] of said lines, a second vacuum tube for re[]peating in the opposite direction, a tran[s]former connecting the input of each of sai[d] repeaters with one of said lines, and a[n] artificial network in shunt to the primar[y] of each of said transformers.

7. In combination, an incoming line, [a] translating device, a transformer having [a] primary winding connected with said li[ne] and a secondary winding connected wit[h] said device, and an impedance in shunt t[o] said primary winding, said impedance hav[]ing such a value that the impedance betwe[en] the points across said line adjacent said im[]pedance, looking in the direction of said im[]pedance and said transformer, closely ap[]proximates the impedance looking from sai[d] points in the direction of said incoming li[ne.]

8. A two-way repeating system compri[s]ing two line sections, a balancing netwo[rk] for each of said line sections, a uni-dire[c]tional path for repeating in one directio[n] between said lines, a second uni-direction[al] path for repeating in the opposite directi[on] between said lines, each of said paths com[]prising a vacuum tube amplifier, a tra[ns]former for coupling said amplifier to o[ne] of said lines, and a resistance element [in] shunt to the primary winding of said tra[ns]former for causing the voltage impresse[d] on the amplifier to be substantially consta[nt] over a wide range of frequencies, said re[]sistance having a value closely approxim[at]ing the resistance of one of said lines an[d] its balancing network connected in parall[el.]

In witness whereof, I hereunto subscri[be] my name this 24th day of June A. D., 191[]

KENNETH S. JOHNSON.

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PAGE

1550

Oct. 20, 1925. 1,558,436

I. LANGMUIR

ELECTRICAL DISCHARGE APPARATUS AND PROCESS OF PREPARING AND USING THE SAME

Original Filed Oct. 16, 1913

Fig.1.

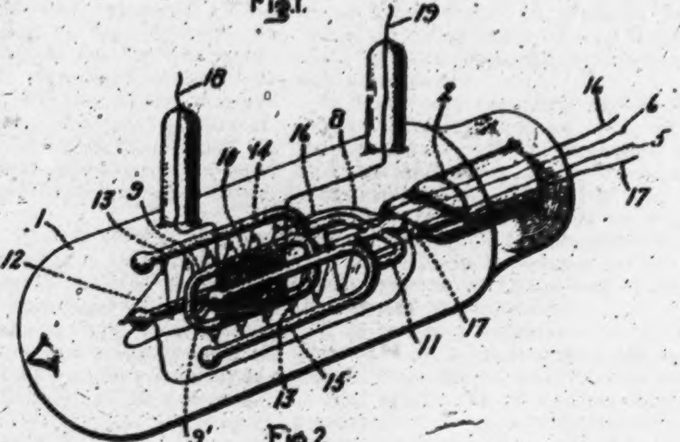


Fig.2.

Fig.3.

Fig.4.

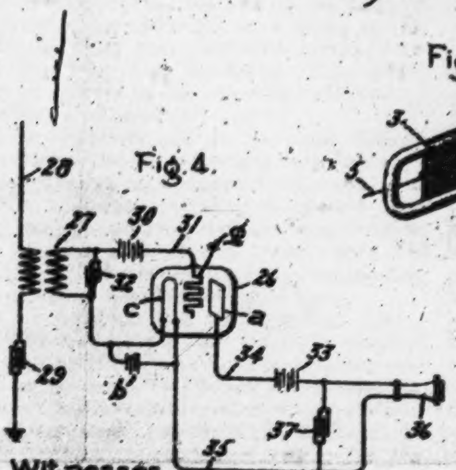
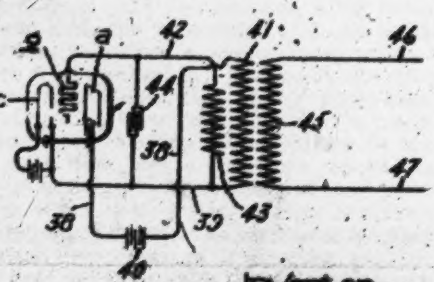


Fig.5.



Witnesses

Inventor
Irving Langmuir
by Albert G. Davis
His Attorney

Patented Oct. 20, 1925. 1,558,436

UNITED STATES PATENT OFFICE.

IRVING LANGMUIR, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

ELECTRICAL DISCHARGE APPARATUS AND PROCESS OF PREPARING AND USING THE SAME.

Application filed October 16, 1913, Serial No. 795,610. Renewed March 14, 1916. Serial No. 84,248.

To all whom it may concern:

Be it known that I, Irving Langmuir, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Electrical Discharge Apparatus and Processes of Preparing and Using the Same, of which the following is a specification.

The present invention relates to electrical vacuum discharge devices, and it comprises devices in which the electrical current is carried by negative charges called electrons, emanating from the cathode, independently of gaseous ionization such as occurring, for example, in the ordinary Roentgen tube.

My present invention comprises improvements in electron-discharge apparatus which make possible a high load capacity and operation with the highest voltages but the invention is also applicable and useful for moderate loads and moderate voltages. The novel features of my invention will be pointed out with greater particularity in the appended claims.

Figs. 1 and 2 of the accompanying drawings, Fig. 2 being a partial view, illustrate two types of discharge devices embodying my invention; Fig. 3 is a fragmental view showing a cathode construction, and Figs. 4 and 5 are diagrams of electrical systems illustrating certain applications of my electron discharge tubes.

In order to distinguish electron discharge devices made in accordance with my invention from the prior art, I will explain briefly the character of a pure electron discharge as distinguished from a discharge through ionized gas. In a Geissler tube, and in a Roentgen or Crookes tube the conduction of current is accompanied by and depends upon gas ionization. Without a certain minimum amount of gas a Roentgen X-ray tube ceases to operate and as this minimum is approached the resistance of the tube steadily increases.

The passage of an electric current across a tube ordinarily involves the movement of negative charges called electrons which, under the influence of the impressed voltage, pass from the cathode to the anode through the vacuous space. If these electrons when moving above a certain velocity collide with gas molecules they tend to ionize the molecules, splitting them up into electrons and larger and more slowly moving ions. Under these circumstances the phenomena of conduction across the tubes are the result of the action and interaction of the electrons and the ions; these phenomena are in general erratic and non-reproducible. The cathode under these conditions is disintegrated, technically it is "sputtered", which causes its rapid destruction. As gas ionization continues at higher voltages a blue glow may appear. The bombardment of the cathode by positive ions also causes heating of the cathode. The ionization of gases at low pressures by collision with electrons occurs at definitely determinable voltages, these voltages being known as the ionization voltages. These voltages are different for different gases. In the case of gases such as nitrogen, hydrogen, oxygen, argon, helium and neon, they are of the order of magnitude of fifteen to twenty-five volts.

The phenomena above described as being characteristic of devices involving gas ionization are taken advantage of in an incandescent cathode device with three electrodes known as the "Audion." This device has been used as a receiver for radio-telegraphy and depends in its operation upon the rapid change of the discharge current when gas ionization begins. This point depends upon various accidental conditions which cause such irregularities in the operation of various devices apparently identical that sometimes only one of a considerable number can be used. Ordinarily the gas ionization in the audion begins to be important somewhere between 20 and 30 volts. Another discharge device previously used to some extent was the Fleming valve. This was a two-electrode tube which, so far as I am aware, was always used at voltages well below the voltages at which positive ionization by collision occurs. It was not evacuated in such a manner as to permit it to be used at voltages materially above these ionization voltages without manifesting substantial positive ionization effects. No prior hot cathode devices are known to me operating with currents as great as about 5 milliamperes with voltages as high as about 200 volts; indeed no prior discharge devices are known to me operating in a practically usable manner and without substantial positive ionization

effects with currents as great as about one-tenth of a milliampere with voltages as high as about forty volts.

In devices made in accordance with my invention gas ionization is either entirely absent or is negligible and a discharge takes place which is distinct in its characteristics from the described discharge taking place in an ionized gas. The cathode is not heated by the discharge itself. Blue glow, glass fluorescence and in fact all readily visible indications of a discharge are ordinarily absent. In most devices of simple construction which embody my invention, the discharge current passing through a given space with the cathode at a sufficiently high temperature with respect to the voltages employed, varies directly with the 3/2 power of the impressed voltages. This 3/2 power law can be readily derived mathematically for a tube in which there is substantially no positive ionization on the assumption that the whole surface of the cathode is at a uniform potential, that the electrons escape from the cathode with negligible velocities and that the walls of the tube do not carry appreciable electric charges.

In most simple devices embodying my invention, these conditions are so well fulfilled that the current does vary in proportion to the 3/2 power of the voltage over wide ranges of voltage above the ionizing voltages. This means that if the logarithm of the current is plotted against the logarithm of the voltage, the resulting plot is a straight line whose slope is 3/2. Or, in many cases it is more convenient to make use of the equivalent relation, that the 2/3 power of the current plotted as ordinates against the anode voltages as abscissæ gives a straight line.

In devices in which there is substantial positive ionization, on the other hand, even when the pressures of gas are so low that only very small currents could be carried by positive ions, the currents begin to increase with voltage more rapidly than according to the 3/2 power law as soon as the anode voltage materially exceeds the ionizing potential of the gas.

In devices embodying my invention which have more than two electrodes, or with special constructions, as where the cathode is a filament, so long that it cannot be considered an equi-potential surface, the 3/2 power law may be more or less masked. However, the effects thus introduced will be readily understood by those skilled in the art, and appropriate methods of identifying the pure electron discharge can easily be found corresponding to the special construction. For example, when such tubes have more than two electrodes and the temperature of the cathode is sufficiently high with respect to the voltages employed, the discharge will usually be characterized by a linear relation between the 2/3 power of the total electron current from the cathode and the voltage applied to any other electrode, the remaining electrodes being kept at constant potential. Another test that can often be made with a three electrode tube is to connect the grid directly to the anode, or to the negative end of the cathode, and observe whether the current varies as the 3/2 power of the voltage.

If for a given cathode temperature the voltage is sufficiently high to cause all of the electrons emitted or liberated at the cathode to be drawn away, then a further increase in voltage produces substantially no change in the current. The current thus determined is called the saturation current, and the range of operation in which the current is substantially independent of the voltage or approaches this condition may be called the saturation range or more briefly designated merely as saturation. If for a given cathode temperature the voltage is not high enough to cause all of the electrons which are emitted or liberated at the cathode to be drawn away, the operation occurs in a range below the saturation range. Operation in this range may be spoken of as operation below saturation.

A change in the temperature of the cathode in a hot cathode device embodying my invention will produce no change in the discharge when the operation is below saturation, even though the ionization voltage is materially exceeded. That is, the current-voltage curve is not changed by a change in the cathode temperature under such conditions.

The discharge in devices embodying my invention is practically independent of the pressure when the pressure is below a certain value which depends upon the size and shape of the device and upon the current and voltage of the discharge.

As distinguished from discharges in the presence of positive ionization, the pure electron discharge is characterized by regularity and reproducibility with given conditions. In a device in which the conduction of current is purely electronic, and the effect of positive ions is negligible, the conduction of current is governed, over a certain range, on the one hand by the effect of the impressed voltage, which tends to propel the electrons across the vacuous space, and on the other hand by the mutual propulsion of the electrons in the space, which tends to limit or inhibit the current. This last mentioned phenomenon, the current limiting effect of the electric field of the electrons on each other, termed the "space charge effect," is discussed and analyzed by me in a paper read before the Physical Society on October 18, 1913, which was abstracted in the Physi-

cal Review for November, 1913, and published in full in the Physical Review for December, 1913, and again published in somewhat modified form in the Physikalische Zeitschrift for April 1, and May 15, 1914. It is the basis of the 3/2 power law referred to herein.

The geometric proportions of the device also affect the amount of current which will pass with a given voltage, but as these conditions remain fixed for a given device they may be represented by a constant in an equation expressing the relation between the current and the voltage.

As stated above, the current (I) in the particular device described herein, when operating below saturation, will vary with the 3/2 power of the voltage (V), the equation being:

$$I = aV^{3/2} \text{ (a being a constant)}$$

As is well known, if we produce a logarithmic graph of any equation in which one variable of the equation varies as a power of the other variable, as for example, an equation of the general form $y=x^n$, (as by plotting logarithms of x as abscissæ and logarithms of y as ordinates) we find that this graph is a straight line. Hence the relation between current and voltage in a device operating below saturation and by pure electronic conduction independent of gas ionization may be expressed by the statement that when with a sufficient electron emission the logarithms of the current values transmitted between cathode and anode are plotted as ordinates against the logarithms of the respective voltages impressed between cathode and anode as abscissæ, the slope of the line obtained does not ordinarily increase for increasing voltage values over a working range of voltages extending materially above the ionization voltages.

A substantial amount of positive ionization ordinarily causes the logarithmic plot of the current with respect to the voltage to bend upwardly and away from the 3/2 power line when the ionizing voltage is materially exceeded. The absence of a bend in the logarithmic plot at voltages somewhat above the ionization voltage is ordinarily a reliable indication that the tube is a pure electron discharge tube, though saturation complete or partial at voltages somewhat greater than the ionization voltages may prevent such a bend in the plot of an ionizing tube.

As above indicated, one of the indications of positive ionization is the occurrence of erratic readings in measuring devices connected in circuit with an electron discharge device under observation. Such erratic readings, of course, will produce a sudden change or discontinuity in the logarithmic graph plotted as above described, and any such irregularities will be more manifest when observed as deviations from a straight line than when the readings are plotted directly.

The effect of positive ionization upon the magnitude of the discharge is especially marked in that region of operation where the current is limited by the space charge effect already discussed, and changes in curvature of the discharge characteristics may occur as indicated unaccompanied by any visible evidence of ionization such as blue glow or the like. At saturation on the other hand, the discharge is ordinarily much less sensitive, and in fact the discharge may actually exhibit marked blue glow effects along with a flat or straight saturation curve.

Devices made in accordance with my invention may be used for various technical purposes, such as relaying and detecting currents, producing oscillations and rectifying alternating currents, and such devices may be made which will operate without substantial positive ionization at voltages far above the ionization voltages with currents thousands of times greater than the currents at which the devices of the prior art were operable without substantial positive ionization. Devices made and operated in accordance with my invention are capable of transmitting currents materially exceeding one-tenth of a milliampere without causing positive ionization to take any essential part in the operation of the device, though the voltage is materially above the ionization voltages.

Before describing the method of preparing my new type of apparatus, I will describe the structure of the apparatus illustrated by Figs. 1 to 3.

As shown in Fig. 1 the various parts of the apparatus may be mounted in a tube, or envelope 1, upon a pedestal 2, similar to the mount used in incandescent lamps. The cathode 3 is centrally located and may consist of a short straight filament not shown in Fig. 1, but indicated by the position of terminals 5, 6, and shown plainly in Fig. 3. The cathode shown in Fig. 2 consists of a V-shaped conductor. Either form may be used, the particular form of cathode being ordinarily determined by convenience of construction. Preferably the cathode conductor is held taut by a spring 7 to avoid contact of the cathode conductor with the grid by sagging when the metal is expanded at a high temperature. The filament 3 is mounted between two oppositely disposed supports, 9, 9', in this case constituting a closed loop, which may consist of insulating material, such as glass or quartz, but in some cases may to advantage consist of metal. Upon this frame-work is wound a discharge-varying conductor 10, ordinarily called a grid. The turns of the wire are closely adjacent to each other and are also very closely

adjacent to but are out of contact with the incandescent cathode. By means of this grid 10 potential may be applied to exert a static control upon the movements of the electrons. A negative potential applied on the grid reduces the flow of current from cathode to anode in proportion to the degree of negative charge. A positive grid potential assists and directs the flow of current from cathode to anode in proportion to the degree of its charge.

The supporting framework for the cathode and grid is attached to a rod 11, mounted upon the stem of the tube. Adjacent to the cathode and grid is the anode 12 which in the present case has been indicated as consisting of a wire strung in a zig-zag manner over hooks 13 upon fork-shaped supports 14 and 15, but it is not necessary that it should assume this particular form. Both anode and grid preferably consist of tungsten, but other refractory metals may be used. By constituting the anode a continuous conductor it can be conveniently heated by passage of current during evacuation of the device and for this purpose is attached to leading-in conductors 16 and 17. The grid is indicated in Fig. 1 as being attached to leading-in conductors 18 and 19 at opposite ends, although but one terminal is ordinarily necessary.

In some cases it is desirable to use a plate-shaped anode; Fig. 2 illustrates such an arrangement suitable particularly for rectifying alternating current. The tube itself and other extraneous parts have not been shown in Fig. 2, as they are similar to Fig. 1. The cathode construction has already been referred to and the anodes 20 and 21 also preferably consist of tungsten and may be connected electrically with each other. Current connections are made by conductors 22, 23, the supports 24, 25 being merely indicated. It will be noted that both in Figure 1 and Figure 2 the electrons are afforded a short and direct path from the cathode to the anode and that this path is so related to the position of the walls of the tube as to minimize the tendency for electrons to pass to the walls of the tube. In such a tube electron bombardment of the walls of the tube is avoided, together with the heating of such walls and the secondary emission of electrons therefrom which said bombardment causes. The energy of the discharge is delivered mainly, or entirely, at the anode, anodes, or upon other interior members instead of at the walls of the tube.

For the evacuation of the device the glass walls of the tube are carefully heated to as high a temperature as the glass will stand without softening and in general the most approved methods of incandescent lamp exhaust are used. The evacuation of the tube preferably while still heated is carried out by means of a suitable evacuating means, for example, a Gaede molecular pump, which removes vapors as well as gases. Chemical evacuating means such as electrically vaporized calcium or magnesium may also be used. Either before or during the evacuation the anodes may be heated, especially when the anodes are to be run at elevated temperature during the normal operation of the device. In this case the temperature is preferably carried close to brilliant incandescence. In the case of the structure shown in Fig. 1, the heating may take place by passing an electrical current through the wire 12. The heating, especially of solid anodes such as shown in Figure 2, may take place in a suitable vacuum furnace, the temperature preferably being raised to 2,500° C. or even higher. Bombardment is a very effective means of removing occluded gas from anodes.

The bombardment is carried out when the evacuation has proceeded to a high degree by applying a potential between the cathode 8 and the anode 12, Fig. 1, the value of which depends upon the character of the device. Care should be taken to use a voltage below that at which a blue glow appears as this indicates harmful gas ionization, and as already pointed out, sputtering and disintegration of the cathode accompanies or closely follows the blue glow phenomenon. The pump should be constantly operated to remove the gas. After the removal of the gas thus driven out the voltage impressed between the cathode and the anode, or anodes, as the case may be, is increased thereby driving out more gas. This process is continued step by step with a progressively higher voltage, the final voltage depending upon the character of the apparatus. In most cases the final voltage should be materially higher than the voltage at which the device is to be used in actual service. However, in the case of devices that use exceedingly high voltages, such as 50,000 volts or even higher, substantially all the gas may be removed from the anode without resorting to voltages higher than the normal operating voltage. In the case of a plate-shaped anode which cannot be readily heated by passage of current, the discharge voltage may be chosen great enough to convey sufficient energy to the anode to raise its temperature to redness or even higher, when the device is to be used with a discharge current adapted to heat the anodes.

After the metal has been freed from occluded gas reabsorption of gas will not readily take place even though it is exposed to the air or other gases. For example, anodes thus treated may be removed to other apparatus which then may be evac-

ated with less electron bombardment of the anode or anodes.

The evacuation of the device should be preferably carried to a pressure as low as a few hundredths of a micron, or even lower, but no definite limits can be assigned. The residual gas pressure should be below the value at which ionization by collision will take place at the given working voltage and current, with its accompanying phenomena of blue glow, disintegration of the cathode, and so forth. When the cathode and anode are located in close proximity and the discharge confined to the region between the same, the permissible pressure is higher than when the cathode and anode are at some distance. It is also true that when the anode has been carefully freed from gas, residual free gas, even if present in a sufficient amount to cause some gas ionization when the apparatus is first started, does little harm, as it is quickly removed by the gas clean-up effect when the device is operated.

Electron discharge apparatus thus provided with a gas-free pretreated anode or anodes, may be constructed to handle currents at a very high voltage by proper mechanical design of the parts subjected to static strains, suitable proportioning of the parts and so forth as described, for example, in my application Serial No. 795,609 filed concurrently herewith upon which Patent 1,273,783 was granted on July 23, 1918.

The asymmetric conductivity existing between the heated and unheated electrodes of a device of the character described may be utilized for various technical purposes. Reference has already been made to the rectification of current. As shown in Fig. an electron discharge tube may be used for detecting electromagnetic waves in radio-telegraphy. As shown in this Fig. the grid g and heated cathode c of an electron discharge tube 26 are connected respectively to the terminals of the secondary of a transformer 27, the primary of which is included in the antenna circuit . The antenna is grounded through a condenser 29 in the usual manner. The cathode c is heated by a local source of energy, as battery b. A battery 30 in the grid circuit 31 has its negative terminal connected to the grid g. A condenser 32 shunts the secondary of the loosely coupled transformer 27. The inductance of the transformer and the capacity of the condenser are adjusted to make the receiving circuit resonant to the frequency of the oscillations to be received. The oscillations set up by the incoming signals are superimposed upon the negative grid potential and cause a variation of current transmitted between cathode c and anode a by a local source of energy such as a battery 33 included in the local or plate circuit 34, 35, of the discharge tube. This circuit is connected to an ordinary telephone receiver 36, preferably shunted by means of a condenser 37, whereby the signals are detected.

Fig. 5 illustrates how an electron discharge tube may be used in a system for producing alternating current from direct current. The anode a and cathode c are connected respectively to conductors 38, 39, one of which includes a local source of energy, such as a battery 40. The terminals of these conductors are connected to an inductive coil 41. The cathode and grid g are also connected respectively by conductors 39 and 42 to a second inductive coil 43 which may be in a variable inductive relation to the coil 41. As soon as a flow of current starts in the plate circuit 38, 39, current is induced in the coil 43 of the grid circuit 39, 42. When by reason of this current the grid becomes negatively electrified, the flow of current in the plate circuit is reduced, and as the plate current decreases the grid electrification changes to positive, which again allows the current in the plate circuit to increase. These changes take place with a frequency depending on the electrical characteristics of the circuits. Across the grid circuit 39, 42, of the discharge tube, in some cases is connected a condenser 44, the capacity of which may be varied to control the frequency of the oscillations set up by the system. The oscillations may be transformed to higher or lower voltage by a transformer coil 45 to the terminals of which are connected transmitting conductors 46, 47. The system shown in Fig. 5 is described and claimed in a copending application, Serial No. 797,-967, filed October 29, 1913.

Residual gas left in a tube when it is sealed off or occluded gas driven off from the inner wall of the tube, or from the electrodes, during the use of the tubes, varies in pressure from time to time according to the conditions of operation of the tube and may produce irregularities in the discharge when operating in the saturation region as well as when operating below saturation. The irregularities below saturation are due mainly to the disturbing effect of the resulting positive ions upon the space charge. The irregularities in the saturation region are due to changes in the rate of emission or liberation of electrons at the cathode. It is obvious that the advantages of stable and reproducible operation and freedom from destructive bombardment of the cathode by positive ions, which advantages are severally or collectively to be secured by the means hereinabove described, are not limited to operation below saturation but are also important in operation in the saturation region.

The positive ionization herein referred to is that positive ionization which occurs as the result of collisions between electrons and gas molecules in the space between the electrodes and causes, as by producing changes in space charge, unstable and non-reproducible operation.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. A discharge tube having electrodes at least one of which is adapted to emit electrons, the gas content or residue of said tube and the relation of the parts of the tube being such that the tube is capable of being so operated in a range below saturation and materially above ionization voltages that the governing or limiting action on the space current due to the electric field of said electrons is substantially unaffected by positive ionization and by secondary electron emission from the walls of the tube.

2. A discharge tube having a cathode adapted to emit electrons and an anode adapted to receive said emitted electrons, the tube walls being fashioned or shaped to permit the direct passage of a useful proportion of said electrons from cathode to anode, the gas content or residue of said tube and the relation of the parts of the tube being such that the tube is capable of being so operated in a range below saturation and materially above ionization voltages that the space current is governed or limited by the electric field of said electrons substantially unaffected by positive ionization.

3. A discharge tube having electrodes at least one of which is adapted to emit electrons, the gas content or residue of said tube and the relation of the parts of the tube being such that the tube is capable of being so operated in a range below saturation and materially above ionization voltages that in that range the space current is governed by the combined effect of the electric field of said electrons and the potentials applied to said electrodes, the governing or limiting of the current being substantially unaffected by positive ionization and by secondary electron emission from the walls of the tube.

4. A discharge device comprising a tube and electrodes therein one of which is adapted to emit electrons, the degree of evacuation and the relation of the parts of the device being such that the device is capable of being so operated, when voltages materially higher than ionization voltages are impressed upon electrodes of the device and when the electron emission has any value such that the space current is below the saturation region at such voltages, that the slope of the line obtained by plotting the logarithms of values of said current as ordinates against the logarithms of the corresponding values of said impressed voltages as abscissæ shows no increase for increasing voltage values.

5. A discharge device comprising a tube and electrodes therein one of which is adapted to emit electrons, the degree of evacuation and the relation of the parts of the device being such that the device is capable of being so operated, when voltages materially higher than ionization voltages are impressed on electrodes of the device and when the electron emission has any value such that the space current is below the saturation region at such voltages, that the line obtained by plotting the logarithms of any values of said current below the saturation region as ordinates against the logarithms of the corresponding values of said impressed voltages as abscissæ is straight and continuous.

6. A discharge tube having electrodes at least one of which is adapted to emit electrons, the gas content or residue of said tube and the relation of the parts of the tube being such that the tube is capable of being so operated, when voltages materially higher than ionization voltages are impressed on electrodes of the tube and when the electron emission has any value such that the space current is below the saturation region at such voltages, that said current varies as the three halves power of said impressed voltages.

7. A discharge device comprising a tube and electrodes therein one of which is an electron emitting cathode, the degree of evacuation of said device and the relation of the parts of the device being such that the device is capable of being so operated, when voltages materially higher than ionization voltages are impressed on electrodes of the device and when the electron emission is such that the space current is below the saturation region at such voltages, that said current is substantially independent of the cathode temperature and unaffected by secondary electron emission from the walls of the tube.

8. A discharge tube having electrodes at least one of which is adapted to emit electrons, the gas content or residue of said tube and the relation of the parts of the tube being such that the tube is capable of being so operated in a range below saturation and materially above ionization voltages that the space current is governed or limited by the combined effect of the electric field of said electrons and the potentials applied to said electrodes, substantially unaffected by positive ionization, the heating effect in the tube due to said current occurring substantially only at one or more of said electrodes.

9. A discharge tube having a cathode adapted to emit electrons, an anode adapted to receive electrons and tube walls fashioned or shaped so as to permit the free passage

of a useful proportion of said electrons from cathode to anode, the gas content or residue of said tube and the relation of the parts of the tube being such that the tube is capable of operation with stable and reproducible results substantially unaffected by positive ionization, with currents of at least 5 milliamperes and with voltages of at least 200 volts.

10. An electrical discharge device comprising a gas-tight envelope, an electron-emitting cathode, a cooperating anode, and a discharge-varying conductor, the space in said envelope being evacuated to below the pressure at which deleterious gas ionization takes place, constituting a device in which the current passed when operated below saturation and over a working range of voltage materially above the ionization voltages is controlled by space charge substantially unaffected by positive ionization.

11. A high vacuum electron discharge device comprising an envelope, an incandescent cathode, and an anode, the space in said envelope being evacuated to such degree that the passage of current produces no appreciable positive ionization when the impressed voltage is as high as 200 volts

12. An electrical discharge device, comprising a gas-tight envelope, an electron emitting cathode, an anode deprived of ionizable gas and a discharge controlling conductor, the space in the envelope being evacuated to a pressure not substantially in excess of a few hundred thousandths of a millimeter of mercury, said device being characterized by the fact that when operated below saturation and materially above the ionization voltages, the current is controlled by space charge substantially unaffected by positive ionization.

13. An electrical discharge device comprising a gas-tight envelope, an electron emitting cathode, a cooperating anode, the space and materials in said envelope being sufficiently free of gas so that substantially no positive ionization occurs when the impressed voltage is as high as 60 volts, and the current over a working range of voltage up to 60 volts varies with the 3/2 power of the impressed voltage.

14. An electrical discharge device comprising a gas-tight envelope, a cathode adapted to be heated to incandescence, an anode from which substantially no ionizable gas can be evolved at operating voltages up to 100 volts with currents up to 1 milliampere, the envelope so shaped and the electrodes so positioned as to substantially avoid secondary electron emission from the wall of the envelope, the space in said envelope being evacuated to a pressure not in substantial excess of a few hundred thousandths of a millimeter of mercury.

15. A device comprising a gas-tight envelope, a cathode adapted to be heated to incandescence, an anode from which no ionizable gas can be evolved at operating voltages up to about 200 volts with operating currents up to about five milliamperes, the space in said envelope being evacuated at a pressure not in substantial excess of a few hundred thousandths of a millimeter of mercury, said device being characterized by the fact that with currents up to about five milliamperes at voltages up to about 200 volts, evidences of positive ionization are substantially absent and the current over a working range below saturation varies with the 3/2 power of the voltage.

16. An electrical discharge device comprising a sealed envelope, an incandescent cathode, and a tungsten anode, said anode deprived of ionizable gas disengageable by electron bombardment, and the space in said envelope being evacuated to a sufficiently low pressure so that current flow produces substantially no phenomena of positive ionization when the impressed voltage is as high as 100 volts and the current is as large as 1 milliampere, and the energy of the discharge is delivered mainly upon said anode.

17. An electron discharge apparatus comprising an envelope, an electron emitting cathode, and an anode, said anode being free of gas disengageable by electron bombardment and said envelope being sufficiently free of gas, so that conduction of current can take place in the evacuated space independently of gas ionization at voltages materially above the ionizing voltages with currents of more than one-tenth of a milliampere, and with the energy of the discharge delivered mainly at said anode.

18. An electrical discharge device comprising a sealed envelope, a cathode, means for producing emission of electrons at said cathode independently of the operating voltage, an anode, and discharge varying means independent of the cathode and anode, said device being freed from gas to such extent that the same is operable to transmit current at an impressed voltage at least as high as about 200 volts without evidences of substantial positive ionization.

19. An electrical discharge device comprising a sealed envelope, an incandescent cathode, an anode and discharge-varying means independent of the cathode and anode, the gas residues in said device being so small that the conduction of current is stable and reproducible over a range of voltage materially above the ionization voltages with currents in excess of one milliampere and with the energy of the discharge delivered mainly upon electrodes.

20. An electrical device comprising the combination of a sealed evacuated envelope, a cathode adapted to be independently heated, and an anode within said envelope,

an external circuit connected to said electrodes, and a source of electro-motive force applied to said circuit, the degree of vacuity and the electron emission of the cathode being so related to the potential of said source that the flow of current over a range of voltage materially above the ionization voltage is governed by the electric field of the electrons in the vacuous space and the potential applied to said electrodes, operatively independent of gas ionization.

21. Apparatus for controlling an electric current comprising a vacuum tube, an anode and an electron emitting cathode in the circuit of said current and within said tube, the degree of evacuation of the tube and the relation of its parts being such that for voltages materially above ionization voltage the current is governed or limited by the electric field of the electrons in said tube substantially unaffected by positive ionization, and a third electrode in said tube by which an auxiliary controlling electromotive force may be superposed to modify the effect of said electric field and control said current in a stable and reproducible manner.

22. The method of controlling an electric current in one circuit by an electromotive force in another circuit which consists in causing said current at voltages materially above ionization voltages to pass as a discharge across a vacuous space between an electron emitting cathode and an anode, maintaining a high vacuum in said space, governing or limiting the current by a space charge effect in said space substantially unaffected by positive ionization, and superimposing the effect of said electromotive force on said space charge effect to control said current in a stable and reproducible manner.

23. A discharge device comprising a tube and electrodes therein, one of which is a cathode, the discharge passing in the main directly between electrodes, the degree of evacuation and the relation of the parts of the device being such that the device is capable of being so operated below saturation and at voltages materially higher than the ionization voltages, that the slope or location of the logarithmic line of current with respect to voltage is not changed by changes in the temperature of the cathode.

24. A discharge device comprising a tube and electrodes therein, one of which is a cathode adapted to be heated and to emit electrons thereby, the discharge passing directly between electrodes, the degree of evacuation and the relation of the parts of the device being such that the device is capable of being so operated below saturation and at voltages materially higher than the ionization voltage, that the plot of the current against the voltage is not changed with changes in the temperature of the cathode.

25. A discharge device comprising a sealed off envelope having therein a cathode adapted to be heated independently of the discharge and to deliver electrons thereby, and an anode, the inner wall of the envelope and the electrodes being sufficiently free of occluded gas, and the free gas within the envelope being such, so that the finished device is capable of sustained operation below saturation in a stable and reproducible manner with currents of more than one milliampere at voltages materially higher than the ionization voltages and with the energy of the discharge delivered mainly at an electrode or electrodes.

26. A discharge device comprising a sealed off envelope and electrodes therein, the envelope being shaped and the electrodes located so that the energy of the discharge is delivered mainly upon one or more of the electrodes, the inner wall of the envelope and electrodes being so free from occluded gas and the pressure in the tube being sufficiently low, with respect to the spacing of the electrodes and the energy of the discharge, so that the device is capable of passing a sustained discharge of one tenth of a milliampere at forty volts, without developing any substantial positive ionization effects.

27. A discharge device comprising a sealed off envelope and electrodes therein, one of which is a cathode adapted to be heated independently of the discharge and to emit electrons thereby, the inner wall of the envelope and the electrodes being so free from occluded gas that the device is capable of passing a sustained discharge of one milliampere at fifty volts with the energy of the discharge delivered mainly at an electrode or at electrodes without liberating any substantial amount of gas into the space within the envelope.

28. A discharge device comprising a sealed-off envelope and electrodes therein, one of which is a cathode adapted to be heated independently of the discharge and to emit electrons thereby, the inner wall of the envelope and the electrodes being so free from occluded gas that the device is capable of passing a sustained discharge of two milliamperes at one hundred volts with the energy of the discharge delivered mainly at an electrode or at electrodes without liberating any substantial amount of gas into the space within the envelope.

29. An electrical discharge device comprising a gas-tight envelope, a cathode adapted to be heated to incandescence, an anode from which substantially no ionizable gas can be evolved at operating voltages up to forty volts with currents up to one-tenth milliampere, the envelope so shaped and the electrodes so positioned as to substantially avoid secondary electron emission from the wall of the envelope, the space in said en-

velope being evacuated to a pressure not in substantial excess of a few hundred thousandths of a millimeter of mercury.

30. In the process of producing a discharge device, removing the occluded gas from the interior surface of the envelope thereof and from the electrodes to such an extent that the finished sealed-off device will operate, without liberating any substantial amount of gas into the space within the envelope, at voltages materially above the ionization voltage with currents greater than one milliampere and with substantially all the energy of the discharge delivered to an anode or anodes.

31. In the process of producing a hot cathode discharge device, treating the interior surface of the envelope and the operating parts to liberate therefrom occluded gas, and removing from the envelope gas liberated by said treatment and free gas originally contained therein, continuing these operations until the occluded and original free gas is so thoroughly removed as to enable the finished sealed-off device to operate below saturation in a stable and reproducible manner at a voltage above fifty volts and with a current greater than one milliampere and with the energy of the discharge delivered mainly at one or more anodes.

32. The process of producing a discharge device which consists in treating the envelope and enclosed parts thereof to liberate gas therefrom and removing from the envelope gas which is thereby liberated and free gas originally contained in the envelope, the treatment being sufficiently powerful and being sufficiently prolonged and the removal of the liberated and original free gas from the envelope being sufficiently thorough, so that the finished sealed-off device is capable of sustained operation substantially without positive ionization at voltages as high as one hundred volts with currents as great as one milliampere and with substantially the entire energy of the discharge delivered upon the anode or anodes of the device.

In witness whereof, I have hereunto set my hand this 15th day of October 1918.

IRVING LANGMUIR.

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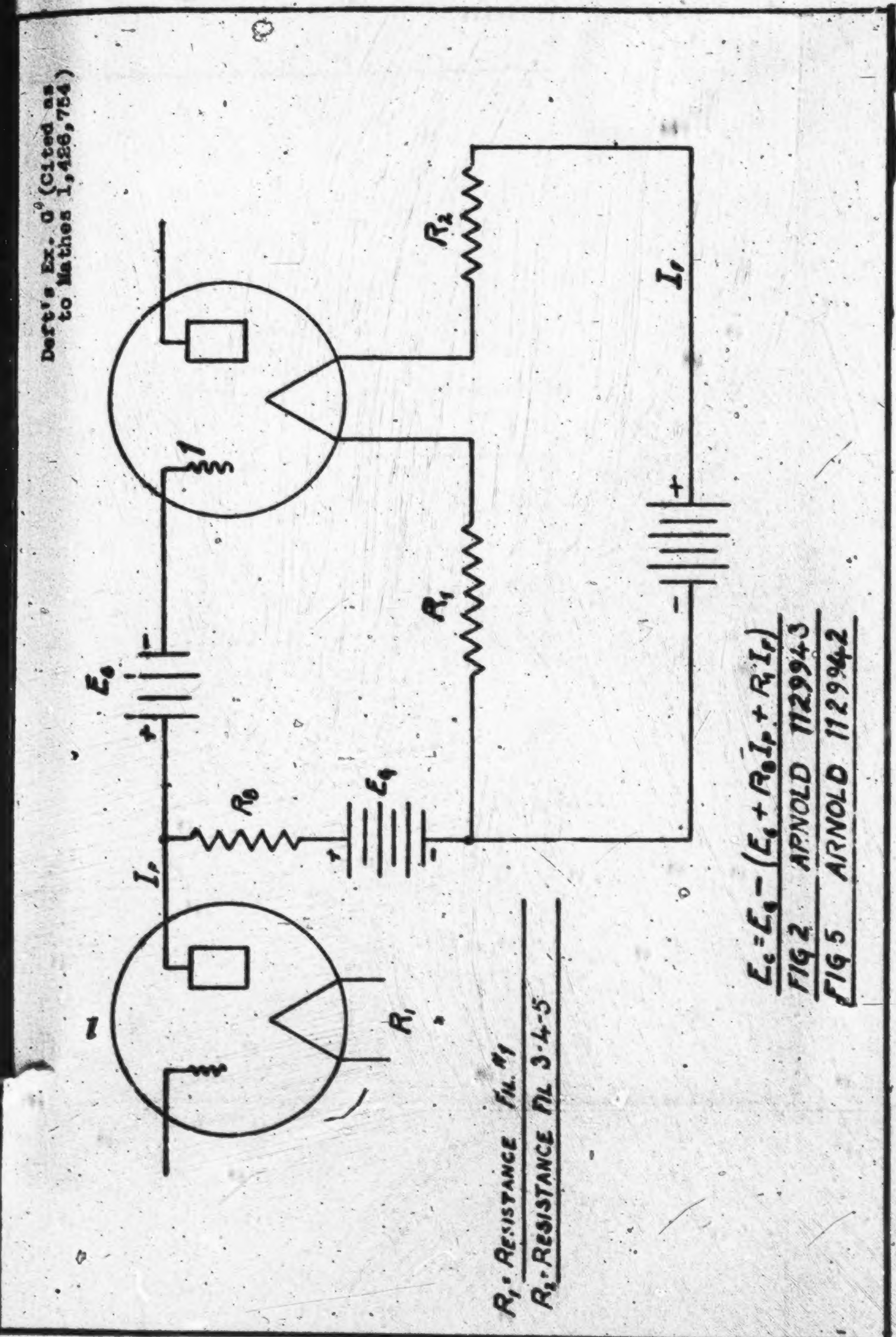
DEFENDANT'S EXHIBIT G



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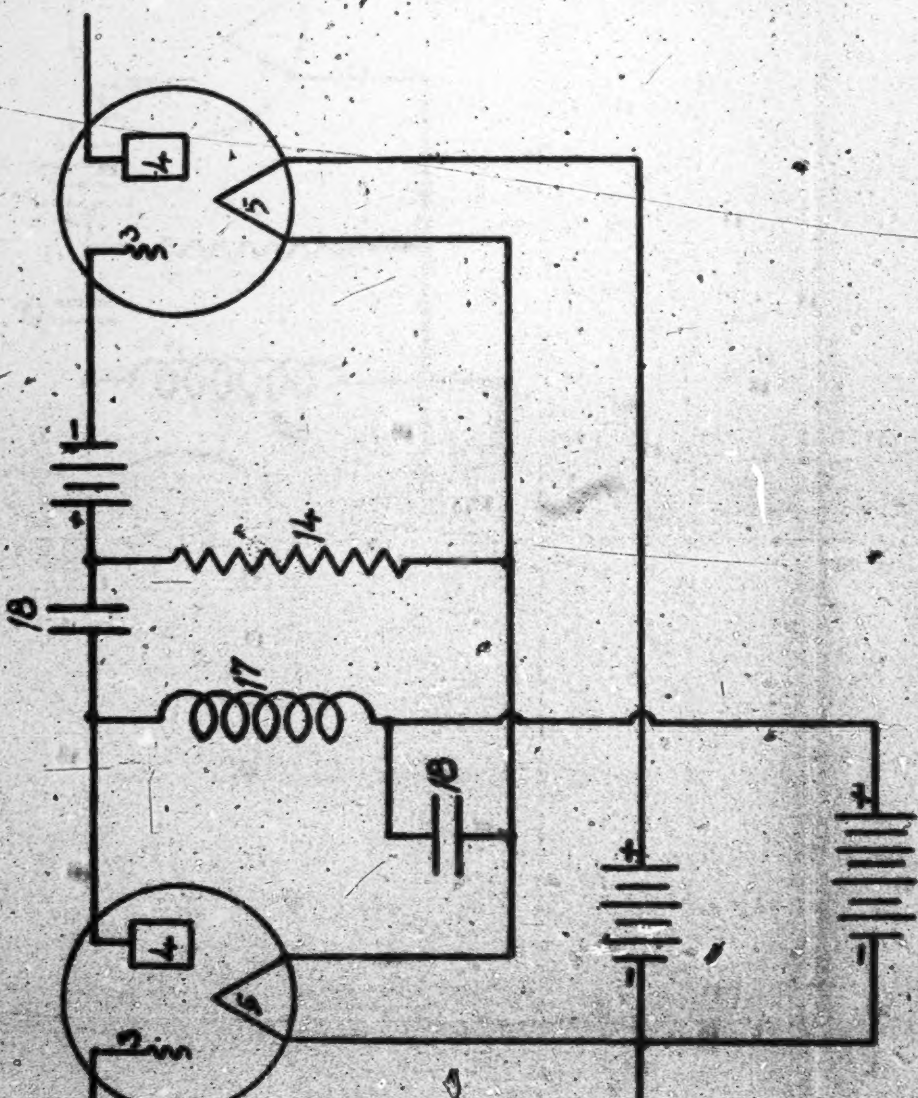

FIG. 6 ARNOLD 1129942 REDRAWN

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DEFENDANT'S EXHIBIT I

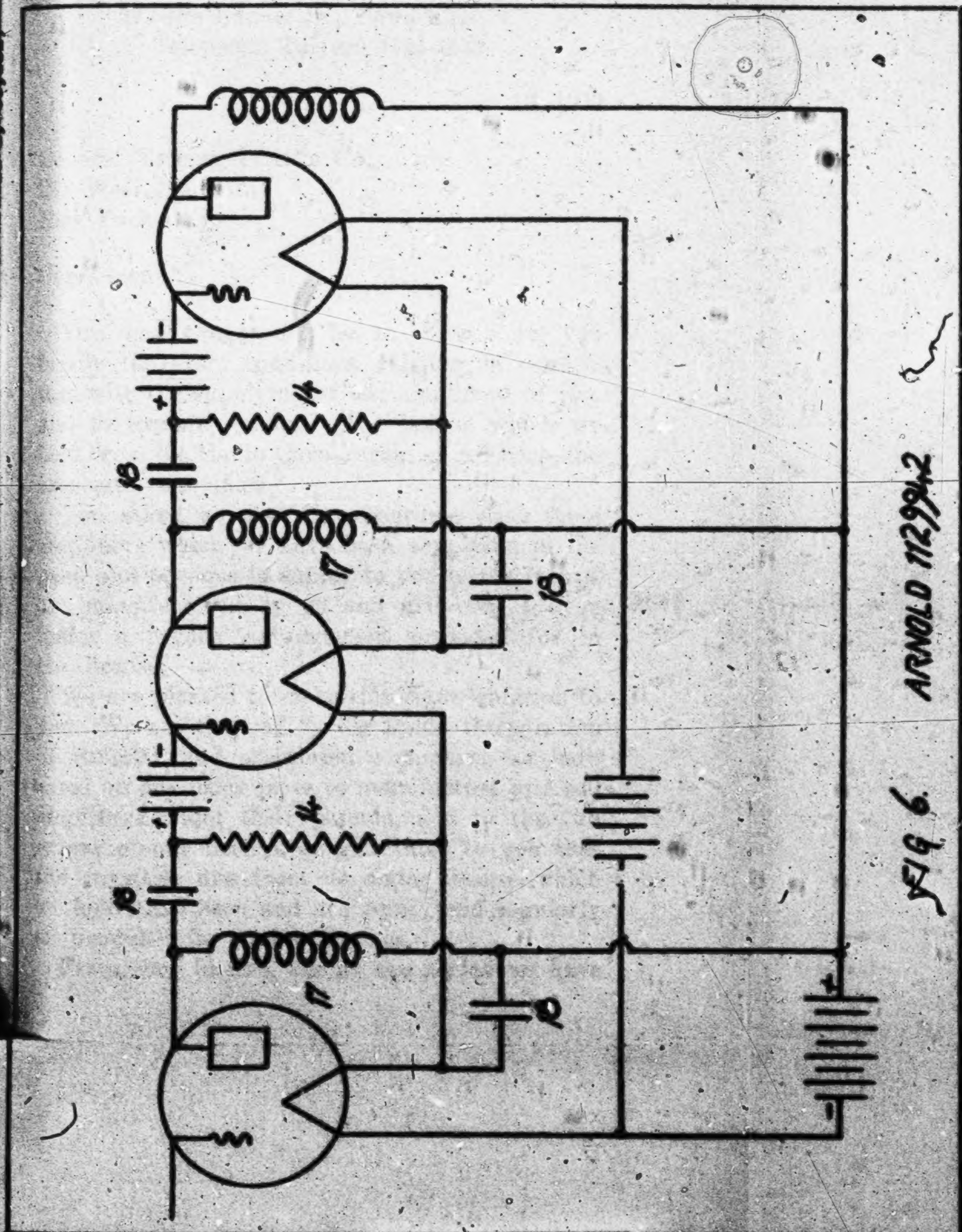

FIG 6

ARNOLD 1129942

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Defendant's Exhibit J. 4687

AMERICAN TRANSFORMER COMPANY
MAKERS OF ELECTRICAL APPLIANCES
172-188 Emmet St., Newark, N. J.
Telephone Terrace 4444-4445

July 16, 1929

General Talking Picture Co.,
218 West 42nd St.,
New York City. 4688

Gentlemen:

You have requested us to outline to you briefly the exact conditions existing in connection with the supplying of our amplifiers to you, and to explain generally the license which we hold from the Radio Corporation of America and associate companies.

You asked us also for assurance that these amplifiers which we have been supplying in the past, and propose to supply to you in the future, are manufactured by us and delivered to you 4689 under a royalty arrangement provided for in the license.

We are pleased to make this representation to you. We are licensed by the Radio Corporation of America and associated companies, as indicated on our name plate to manufacture and sell amplifiers under their patents, and to the full extent of our license we guarantee to you that the royalties due from us under license which we hold have been and are being paid regularly as provided for in the licenses.

From time to time during the period we have

been supplying our amplifiers to you, we have had interviews with a Representative of the Western Electric Company, in which it was mentioned that we had been supplying these amplifiers freely to you and others and no question has been raised as to our right to make such sales. As a matter of fact, our books are open to inspection by the Radio Corporation of America and they are fully aware of the fact that we are dealing with you and they have raised no
4691 objection whatsoever.

We have been informed that a Representative of the Western Electric Company has examined one of these amplifiers which you had installed in a theatre, and as to that particular amplifier he stated that it appeared to be a very high grade product.

In view of the foregoing, we are quite prepared and do hereby undertake to continue to supply you with as many amplifiers as you may in reason require from time to time during the term of our present license, and particularly in
4692 view of your contemplated larger orders, you are entitled to our specific undertaking not to discontinue for any reason whatsoever other than non-payment of moneys due us if any.

We hereby give you an option to order from us two thousand (2,000) amplifiers, on the same terms and conditions as amplifiers have been heretofore supplied to you. The price to be mutually agreed upon. The period of said option to continue for one year from the date hereof and said amplifiers to be furnished and supplied as promptly as reasonably can be done.

Provided you shall have fulfilled all the terms

and conditions of the order during such one year period, we hereby grant you an option for another year provided we have a license upon the same term as at present to manufacture such amplifiers.

Very truly yours,

AMERICAN TRANSFORMER COMPANY
CHAS. F. LOUGHEAD
President. 4694

Defendant's Exhibit K.

AMERICAN TRANSFORMER COMPANY
MAKERS OF ELECTRICAL APPLIANCES
172-188 Emmet St., Newark, N. J.

Telephone Terrace 4444-4445

July 24th, 1929
4695

General Talking Pictures Corp.,
218 West 42nd Street,
New York City.

Gentlemen:

You have requested us to outline to you briefly the exact conditions existing in connection with the supplying of our amplifiers to you, and to explain generally the license which we hold from the Radio Corporation of America and Associated companies.

You asked us also for assurance that these

amplifiers that we have been supplying in th
past and propose to supply to you in the futur
are manufactured by us and delivered to yo
under a royalty arrangement provided for i
the license.

We are pleased to make this representation t
you. We are licensed by the Radio Corporatio
of America and associated companies, as ind
cated on our name plate, to manufacture an
sell amplifiers under their patents, and to th
4697 full extent of our license we guarantee to yo
that the royalties due from us under licens
which we hold have been and are being pai
regularly as provided for in the licenses.

From time to time during the period we hav
been supplying our amplifiers to you, we hav
had interviews with a representative of th
Western Electric Co. in which it was mentione
that we have been supplying these amplifier
freely to you and others and no question ha
been raised as to our right to make such sale
As a matter of fact, our books are open to in
4698 spection by the Radio Corporation of Americ
and they are fully aware of the fact that we ar
dealing with you and they have raised no ob
jection whatsoever.

In view of the foregoing, we are quite pre
pared and do hereby undertake to continue t
supply you with as many amplifiers as you ma
in reason require from time to time during th
term of our present license, and particularly i
view of your contemplated larger orders, yo
are entitled to our specific undertaking not t
discontinue for any reason whatsoever other tha
non-payment of moneys due us if any.

We hereby give you an option to order from us two thousand (2,000) amplifiers on the same terms and conditions as amplifiers have been heretofore supplied to you and the period of said option to continue one year from the date hereof; and we hereby grant you a continuing option from year to year during the term of which we have license to manufacture such amplifiers, provided you shall have fulfilled all the terms and conditions of each preceding year, and we agree on our part not to mutually arrange with the 4700 licensor under whom we manufacture, to cancel such license. We agree to exercise full reasonable care and diligence to make deliveries on your orders as required so far as possible within reasonable manufacturing practice.

American Transformer Company
Chas. F. Loughead
President

4701

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PAGE

DEFENDANT'S EXHIBIT L

AMERICAN TRANSFORMER COMPANY
MAKERS OF ELECTRICAL APPLIANCES
172-188 EMMET ST., NEWARK, N. J.
Terrace [illegible] July 26, 1929

Mr. Chas. J. Ross, Comptroller,
Radio Corporation of America,
233 Broadway,
New York City.

Dear Sir:

We are enclosing our check for $5225.45 same being Royalty due for material sold during the second quarter of this year as per attached statement.

We trust you will find this correct, and remain

Very truly yours,

AMERICAN TRANSFORMER COMPANY.
Chas. L. Lougheed
Pres.

Encl. 2

7/27/9

1569

AMERICAN TRANSFORMER COMPANY

MAKERS OF ELECTRICAL APPLIANCES

172-188 EMMET ST., NEWARK, N. J.

TELEPHONE TERRACE [illegible]

REPORT SECOND QUARTER 1929

APRIL- MAY - JUNE

1929

	MODEL #1	MODEL #2	MODEL #3	MODEL 5	MODEL #6	MODEL #7
April 1st	6	4	1	-	-	-
2d	-	-	-	2	-	-
3d	-	-	-	-	-	-
4th	-	-	-	2	-	-
5th	-	-	-	-	-	-
6th	-	-	-	-	-	-
7th	-	-	-	-	-	-
8th	-	1	-	-	-	-
9th	1	1	-	2	-	-
10th	1	1	-	1	-	-
11th	-	-	-	4	-	-
12th	-	-	-	5	-	-
13th	-	-	-	-	-	-
14th	-	-	-	-	-	-
15th	-	-	-	1	-	-
16th	-	-	-	-	-	-
17th	-	-	-	-	-	-
18th	2	1	-	2	-	1
19th	-	-	-	4	-	-
20th	-	-	1	9	-	-
21st	-	-	-	-	-	-
22d	-	-	-	-	-	-
23d	5	4	-	-	-	-
24th	-	-	-	3	-	-
25th	-	-	-	-	-	-
26th	-	-	-	5	-	-
27th	-	-	-	5	-	16
28th	-	-	-	-	-	-
29th	-	-	-	1	-	-
30th	-	-	-	-	-	-
31st	-	-	-	-	-	-
Total ---	15	12	2	46	-	17

Apr. 23- Spec. Amplifier

Total to be Deducted from Sales -

116 - #13377 @ $28.00 less, less 50 - 10% = $1461.60

1570

AMERICAN TRANSFORMER COMPANY

MAKERS OF ELECTRICAL APPLIANCES

172-188 EMMET ST., NEWARK, N. J.

TELEPHONE TERRACE 4444 4445

1929	MODEL #1	MODEL #2	MODEL #3	MODEL #5	MODEL #6	MODEL #7
May 1st	-	-	-	6	-	13
2d	-	1	-	-	-	-
3d	-	-	-	-	-	-
4th	-	-	-	-	-	-
5th	-	-	-	-	-	-
6th	-	-	-	-	-	-
7th	-	-	-	-	-	16
8th	-	-	-	-	-	8
9th	-	-	-	7	-	-
10th	-	-	-	-	-	10
11th	-	-	-	-	-	-
12th	-	-	-	-	-	-
13th	1	-	-	8	-	10
14th	1	-	-	-	-	1
15th	-	1	-	-	-	-
16th	-	-	-	-	-	6
17th	2	2	-	-	-	-
18th	-	-	-	-	-	-
19th	-	-	-	-	-	-
20th	-	-	-	-	-	-
21st	-	-	-	5	-	8
22d	1	-	-	-	-	7
23d	-	-	-	-	-	-
24th	-	-	-	1	-	1
25th	-	-	-	-	-	-
26th	-	-	-	-	-	-
27th	1	1	-	10	-	7
28th	1	1	-	-	-	-
29th	-	-	-	-	-	-
30th	-	-	-	-	-	-
31st	-	-	-	4	-	8
Total---	7	6	-	41	-	95

May 18th - Spec. Amplifier

32	Model	#1 @ $36.00	=	$	1152.00
1	"	#1 @ $22.40	=		22.40
29	"	#2 @ $57.00	=		1653.00
1	"	#2 @ $51.30	=		51.30
5	"	#3 @ $21.60	=		108.00
104	"	#5 @ $425.	=		44200.00
2	"	#5 @ $648.	=		1296.00
5	"	#5 @ $550.	=		2750.00
5	"	#5 @ $625.	=		3125.00

135

Forward

1571

AMERICAN TRANSFORMER COMPANY

MAKERS OF ELECTRICAL APPLIANCES

172-186 EMMET ST., NEWARK, N. J.

19[illegible]

June	Model #1	MODEL #2	MODEL #3	MODEL #5	MODEL #6	MODEL #7	MODE[L]
1st	-	-	-	4	-	-	-
2d	-	-	-	-	-	-	-
3d	1	-	-	-	-	-	-
4th	-	-	-	-	-	4	-
5th	-	-	-	-	-	-	-
6th	-	-	-	-	1	-	-
7th	-	-	1	-	-	-	-
8th	1	-	-	-	2	-	-
9th	-	-	-	-	-	-	-
10th	-	-	-	-	-	-	-
11th	-	-	-	-	2	12	-
12th	-	-	-	4	-	6	-
13th	-	-	2	12	-	-	-
14th	-	-	-	-	-	8	-
15th	-	2	-	-	2	-	-
16th	-	-	-	-	-	-	-
17th	2	3	-	-	-	-	-
18th	5	3	-	-	-	-	-
19th	-	-	-	-	-	-	1
20th	-	-	-	-	-	14	-
21st	1	1	-	-	-	-	4
22d	-	-	-	-	-	-	-
23d	-	-	-	-	-	-	-
24th	-	-	-	-	-	6	-
25th	-	-	-	1	5	-	-
26th	-	-	-	-	-	-	2
27th	2	1	-	5	-	-	5
28th	1	-	-	5	1	16	-
29th	2	2	-	-	-	6	3
30th	-	-	-	-	-	-	-
	15	12	3	30	13	72	15

13 Model #6 @ $225.00 = $ 2925.00
184 " #7 @ $ 60.00 = 11040.00
15 " #8 @ $ 40.00 = 600.00
Apr. 23d Spec. Amplifier 200.00
May 18th " " 200.00
Total [illegible]
7 1/2% Royalty on $[illegible]72.70 = $[illegible]
amount of check we are attaching.

1572

#11

AMERICAN TRANSFORMER COMPANY
MAKERS OF ELECTRICAL APPLIANCES
172-186 EMMET ST., NEWARK, N. J.
TELEPHONE [illegible]

Oct 28, 1929

Mr. Chas. J. Ross, Comptroller,
Radio Corp. of Am.,
233 Broadway,
New York City.

Dear Sir:

We are enclosing our check covering Royalties due for the third quarter of this year as per attached statement.

Below we give data as to just how this is arrived at:

5	Model	#1	@ $36.00	-------------	180.00
9	"	#2	87.50	-------------	813.00
1	"	#3		-------------	81.00
1	"	#3	Special	-------------	88.50
50	"	#5	@ $[illegible].00	-------------	11760.00
10	"	#5	$411.50	-------------	4115.00
15	"	#5	[illegible].00	-------------	6375.00
2	"	#5	[illegible].00	-------------	975.00
19	"	#5	[illegible]	-------------	9800.00
1	"	#6		-------------	261.00
15	"	#6	225.00	-------------	3375.00
1	"	#7	Special	-------------	135.00
140	"	#7	@ $55.00	-------------	7700.00
74	"	#7	55.00	-------------	[illegible]
12	"	#8	50.00	-------------	600.00
28	"	#9	240.00	-------------	6720.00
11	"	#9	265.00	-------------	2915.00
25	"	#9	@ $275.00	-------------	[illegible]
6	"	#9	310.00	-------------	1860.00
1	"	#9	360.00	-------------	360.00
1	"	11		-------------	200.00
4[illegible]					$[illegible].70

6647.10

7 1/2% of $66472.10 = $4994.45 amount of check we are enclosing.

We trust you will find this correct, and remain,

Very truly yours,

AMERICAN TRANSFORMER COMPANY.

J. L. Schermerhorn

JLS-

10/29/29

Total to be Deducted from [illegible]

76- #13377 less $78.00 less 50-10% = $957.60

64- #13576 no $20.00 no = 576.00

$1533.60 128

972.00

1573

AMERICAN TRANSFORMER COMPANY

MAKERS OF ELECTRICAL APPLIANCES

172-186 EMMET ST., NEWARK, N. J.

TELEPHONE TERRACE [illegible]

1929.		Model #1	Model #2	Model #5	Model #6	Model #7	Model #8	Model
July	1st	-	-	-	-	8	-	-
	2d	1	2	-	4	-	14	-
	3d	-	-	-	-	-	-	-
	4th	-	-	-	-	-	-	-
	5th	1	1	-	4	-	-	1
	6th	-	-	-	-	10	-	-
	7th	-	-	-	-	-	-	-
	8th	-	-	-	6	-	-	-
	9th	-	-	1	-	-	-	-
	10th	-	-	-	-	-	-	-
	11th	-	-	-	-	-	-	-
	12th	1	1	-	2	-	-	-
	13th	-	-	-	-	-	1	1
	14th	-	-	-	-	-	-	-
	15th	-	-	-	-	-	-	-
	16th	-	-	-	-	-	-	-
	17th	1	1	-	-	20	-	-
	18th	-	-	1	-	-	-	-
	19th	-	-	-	-	-	-	-
	20th	-	-	-	-	-	-	-
	21st	-	-	-	-	-	-	-
	22d	-	-	-	-	6	-	-
	23d	-	-	-	-	-	-	-
	24th	1 returned	1 returned	12	-	-	-	-
	25th	-	-	3	-	-	-	-
	26th	-	-	-	-	-	-	-
	27th	-	-	-	-	-	-	-
	28th	-	-	-	-	-	-	-
	29th	-	-	-	-	-	-	-
	30th	-	-	-	-	20	-	3
	31st	-	-	-	-	-	-	-
		3	4	15	16	64	15	5

151 122

19

Aug.

AMERICAN TRANSFORMER COMPANY
MAKERS OF ELECTRICAL APPLIANCES
172-188 EMMET ST., NEWARK, N. J.
TELEPHONE TERRACE | 4444 4445

29

.	Model #1	Model #2	Model #3	Model #5	Model #7	Model #9
1st	-	-	-	-	-	2
2d	-	1	-	-	-	2
3d	-	-	-	-	-	[illegible]
4th	-	-	-	-	-	-
5th	-	-	-	-	14	2
6th	-	-	-	-	-	2
7th	-	-	-	-	-	-
8th	-	-	-	-	-	3
9th	-	-	-	13	-	3
10th	-	-	-	-	8	-
11th	-	-	-	-	-	-
12th	-	-	-	-	-	-
13th	1	1	-	-	-	9
14th	-	-	-	-	-	-
15th	-	1	-	-	-	-
16th	-	-	-	-	6	-
17th	-	-	-	-	-	-
18th	-	-	-	-	-	-
19th	-	-	-	1	-	2
20th	1	1	-	-	-	1
21st	-	-	-	1	14	-
22d	-	-	-	-	8	-
23d	-	-	-	-	16	8
24th	-	-	-	-	-	-
25th	-	-	-	-	-	-
26th	-	-	-	-	12	10
27th	-	-	-	-	8	9
28th	-	-	-	-	-	-
29th	-	-	1	-	-	-
30th	-	1	-	-	-	-
31st	-	-	-	-	-	-
	2	5	1	15	86	56

130 163

1575

AMERICAN TRANSFORMER COMPANY

MAKERS OF ELECTRICAL APPLIANCES

172-188 EMMET ST., NEWARK, N. J.

TELEPHONE TERRACE 4444 / 4445

1929.

		Model #3	Model #5	Model #7	Model #9
Sept.	1st	-	-	-	-
	2d	-	-	-	-
	3d	-	5	20	-
	4th	-	-	-	-
	5th	-	15	12	-
	6th	-	-	10	-
	7th	-	-	6	-
	8th	-	-	-	-
	9th	-	5	-	-
	10th	-	-	-	-
	11th	-	-	-	-
	12th	-	-	-	-
	13th	-	-	11	-
	14th	-	-	-	-
	15th	-	-	-	-
	16th	-	-	-	-
	17th	-	-	-	-
	18th	1	-	-	-
	19th	-	-	-	-
	20th	-	-	-	-
	21st	-	-	-	1
	22d	-	-	-	-
	23d	-	-	-	-
	24th	-	-	6	5
	25th	-	-	-	5
	26th	-	-	-	-
	27th	-	[illegible]	-	-
	28th	-	-	-	-
	29th	-	-	-	-
	30th	-	11	-	-
	31st	-	-	-	-
		1	46	65	11

123
163
122
408

48

129

127

AMERICAN TRANSFORMER COMPANY
MAKERS OF ELECTRICAL APPLIANCES
172-186 EMMET ST., NEWARK, N. J.
TELEPHONE TERRACE

Dec. 7th, 1929

Mr. Chas. J. Ross, Comptroller,
Radio Corporation of America,
233 Broadway, New York City.

Dear Sir:-

A revision of our cost system has revealed some slight errors in our report to you of October 26th covering the sales of amplifiers, and in which we enclosed our check amounting to $4994.43. This was based on the total sales for the third quarter amounting to $67925.70.

We are enclosing herewith the revised list of sales grouped according to months giving the names of the customers, billing prices, deductions for returned apparatus and cash discounts. There are individual sheets for July, August and September and a summary sheet totaling the net sales for the three months. This shows that the royalty which should have been paid amounts to $4902.47, and indicates that we paid in excess $91.96 which we are quite willing to have credited against sales for the last quarter of this year.

We trust that this correction is in order and that your records will agree with ours.

If we can be of any further service in this matter do not hesitate to call upon us.

Yours very truly,

AMERICAN TRANSFORMER COMPANY
J. L. Schermerhorn
J.L. Schermerhorn
Vice President

JLS/MS
Enc. 4 sheets

AMERICAN TRANSFORMER COMPANY
MAKERS OF ELECTRICAL APPLIANCES
172-188 EMMET ST., NEWARK, N. J.
TELEPHONE TERRACE

GENERAL SUMMARY FOR
JULY, AUGUST, & SEPTEMBER

MONTH	NET AMOUNT BILLED
July	$15,182.60
August	24,458.60
September	25,725.10
Total	$65,366.30
7½% Royalty	4,902.47

Royalty Actually Paid	$4,994.43
Amt. Royalty Corrected	4,902.47
Excess Royalty Paid	$ 91.96

Excess Royalty to be credited against last quarter 1929.

AMERICAN TRANSFORMER COMPANY

TRANSFORMER SPECIALISTS
ELECTRICAL APPLIANCES

172-180 EMMET STREET
NEWARK, NEW JERSEY

Telephone Terrace
[illegible]

JULY 1929 SALES

2nd	Gen. Talk.Pict.	3	Model #6	@ $225. ea.	$ 675.00*
	" " "	8	" 7 "	60. "	480.00*
5th	" " "	4	" 6 "	225. "	900.00*
	" " "	1	" 9 "	265. "	265.00
2nd	Dr. I. Kitse	1	" 6 "	261. "	261.00
5th	Gen.Talk.Pict.	10	" 7 "	60. "	600.00*
8th	" " "	4	" 6 "	225. "	900.00*
11th	Best Mfg. Co.	1	" 5 "	425. "	425.00
12th	Gen.Talk.Pict.	2	" 6 "	225. "	450.00*
13th	DeForest Phono.	1	" 9 "	265. "	265.00
	Gen.Talk.Pict.	1	" 8 "	40. "	40.00*
17th	" " "	20	" 7 "	55. "	1100.00*
18th	Best Mfg.Co.	1	" 5 "	425. "	425.00
22nd	Gen.Talk.Pict.	6	" 7 "	55 "	330.00*
24th	DeForest Phono.	10	" 5 "	411.50"	4115.00
	" "	2	" 5 "	486.50"	973.00
25th	Best Mfg.Co.	1	" 5 "	425 "	425.00
30th	Gen.Talk.Pict.	20	" 7 "	55. "	1100.00 *
	" " "	3	" 9 billed @		
	$275 less Cr.$35.to correct			240. "	720.00*
2nd	Gen.Talk.Pict.	14	" 7 "	40. "	560.00*
2nd	Universal Wireless	1	" 1 "	36. "	36.00
	" "	2	" 2 "	57. "	57.00
5th	Wm. Rickey	1	" 1 "	36. "	36.00
	" "	1	" 2 "	57. "	114.00
12th	H.W.Projector Co.	1	" 1 "	36. "	36.00
	" "	1	" 2 "	57. "	57.00
17th	Triple Reflecting Arc Lamp	1	" 1 "	36. "	36.00
	" " "	1	" 2 "	57. "	57.00
				Total	$15438.00

CREDET

24th	Biophone Corp.	1	" 2 "	57.	
		1	" 1 "	36.	93.00
					$15345.00

Discount
*Less 2% Cash on $8120.00 ---------- 162.40
$15182.60

123

1579

AMERICAN TRANSFORMER COMPANY

TRANSFORMER SPECIALISTS
ELECTRICAL APPLIANCES

172-188 EMMET STREET
NEWARK, NEW JERSEY

Telephone [illegible]
[illegible]

AUGUST 1929 SALES

Aug.	5th	Gen.Talk.Pict. ✓	14 Model #7 @ $	55. ea.	---------$	770.00*
	9th	DeForest Phonofilm ✓	2 " 5 "	500. "	----------	1000.00
		" " ✓	11 " 5 "	425. "	----------	4675.00
	5th	Gen.Talk.Pict. ✓	2 " 9 billed @			
		$275.less Cr.$35.to correct		240. "	----------	480.00*
		Gen.Talk.Pict. ✓	2 " 9 billed @			
		$275.less Cr.$35. to correct		240. "	----------	480.00*
	6th	Gen.Talk.Pict ✓	2 " 9 billed @			
		$275.less Cr.$35. to correct		240. "	----------	480.00*
	7th	Gen.Talk.Pict ✓	3 " 9 billed @			
		$275. less Cr.$35.to correct		240. "	----------	720.00*
	9th	Gen.Talk.Pict. ✓	3 " 9 billed @			
		$275. less Cr.$35. to correct		240. "	----------	720.00*
	10th	Gen.Talk.Pict. ✓	8 " 7 @	55. "	----------	440.00*
	13th	" " "	9 " 9 billed @			
		$275.less Cr.$35.to correct		240. "	----------	2160.00*
	13th	Gen.Talk.Pict. ✓	2 " 9 billed @			
		$275.less Cr. $35.to correct		240. "	----------	480.00*
	16th	Gen.Talk.Pict. ✓	6 " 7 @	55. "	----------	330.00*
	19th	DeForest Phonofilm ✓	2 " 9 billed @			
		$310.less Cr.$45 to correct		265. "	----------	530.00
	17th	DeForest Phonofilm ✓	2 " 5 @	500. "	----------	1000.00
	20th	Gen.Talk.Pict. ✓	10 " 7 "	55. "	----------	550.00*
	21st	" " " ✓	4 " 7 "	55. "	----------	220.00*
		" " " ✓	1 " 5 billed @			
		$425.less Cr. to correct		400. "	----------	400.00*
	20th	Gen.Talk.Pict. ✓	10 " 7 @	55. "	----------	550.00*
	22nd	" " " ✓	8 " 7 "	55. "	----------	440.00*
	23rd	" " " ✓	8 " 9 "	240. "	----------	1920.00*
		" " " ✓	6 " 7 "	55. "	----------	330.00*
	26th	" " " ✓	12 " 7 "	55. "	----------	660.00*
		" " " ✓	10 " 9 "	240. "	----------	2400.00*
	20th	Moffett	1 " 9 "	410. "	----------	410.00
	27th	DeForest Phonofilm ✓	3 " 9 billed @			
		$310.less Cr.$45. to correct		265. "	----------	795.00
	27th	Gen.Talk.Pict. ✓	8 " 7 @	55. "	----------	440.00*
	28th	" " " ✓	10 " 7 "	55. "	----------	550.00*
	29th	" " " ✓	10 " 7 "	55. "	----------	550.00*
	2nd	Carrier Constr. ✓	1 " 2 "	57. "	----------	57.00
	13th	Theo.Chrisomalis	1 " 1 "	36. "	----------	36.00
		" "	1 " 2 "	57. "	----------	57.00
	15th	Jenkins Television ✓	1 " 2 "	57. "	----------	57.00
	29th	Arcturus Tube ✓	1 " 1 "	36. "	----------	36.00
	30th	Westinghouse Elec.	1 " 2 "	57. "	----------	57.00
				Total		$24780.00
		*2% Cash Disc. on $16070				321.40
				124		$24458.60

AMERICAN TRANSFORMER COMPANY

TRANSFORMER SPECIALISTS
ELECTRICAL APPLIANCES

17[illegible]-180 EMMET STREET
NEWARK, NEW JERSEY

Telephone [illegible]
[illegible]—[illegible]—[illegible]—[illegible]

SEPTEMBER 1929 SALES.

Sept.	3rd	Gen.Talk.Pict. ✓	16	Model	#7	@ $ 55. ea.	---------$	880.00*
		" " " ✓	4	"	7	" 55. "	----------	220.00*
		" " " ✓	5	"	5	" 400. "	----------	2000.00*
		" " " ✓	12	"	7	" 55. "	----------	660.00*
	5th	DeForest Phonofilm ✓	15	"	5	" 500. "	----------	7500.00
		Gen.Talk.Pict ✓	10	"	7	" 55. "	----------	550.00*
	6th	" " " ✓	6	"	7	" 55. "	----------	330.00*
	7th	" " " ✓	5	"	5	" 400. "	----------	2000.00*
	9th	" " " ✓	10	"	7	" 55. "	----------	550.00*
	12th	DeForest Phonofilm ✓	1	"	9	" 340. "	----------	340.00
	17th	" "	1	"	2	" 58.50"	----------	58.50
	18th	Walthal --	1	"	9	" 265. "	----------	265.00
	21st	DeForest Phonofilm ✓	5	"	9	" 240. "	----------	1200.00*
	23rd	Gen.Talk.Pict. ✓	5	"	9	" 240. "	----------	1200.00*
	24th	" " " ✓	6	"	7	" 55. "	----------	330.00*
	24th	" " " ✓	10	"	5	" 400. "	----------	4000.00*
	27th	" " " ✓	10	"	5	" 4000. "	----------	4000.00*
	30th	" " " ✓				Total		$26083.50
						* 2% Cash Disc. on $17920		358.40
								$25725.10

.35

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STATEMENT

AMERICAN TRANSFORMER COMPANY

MAKERS OF

ELECTRICAL APPLIANCES

174-188 EMMET STREET

NEWARK, N. J.

#12

1-29-30

Radio Corp. of America,
233 Broadway,
New York City.

EXAMINE THIS STATEMENT. WE RENDER ACCOUNTS ON THE FIRST OF EACH MONTH OF ALL ITEMS AS THEY APPEAR ON OUR LEDGER. IF ANY ERRORS OR OMISSIONS PLEASE ADVISE.

CHARGES			CREDITS		
DATE	MEMO.	AMOUNT	DATE	MEMO.	AMOUNT
FIRST OF MONTH BALANCE $					

SUMMARY OF SALES

1929	October	Sales net	21,781.65	16[illegible]
	November	" "	10,798.50	7[illegible]
	December	" "	16,425.85	16[illegible]
			49,006.00	40[illegible]

Royalties @ 7½%	3,675.45
Less:- overpayment three months ending September 30, 1929	91.96
	3,583.49 Ledger

END OF MONTH BALANCE $

Total Sales to be deducted
$1148.40

118

1582

12

AMERICAN TRANSFORMER COMPANY

TRANSFORMER SPECIALISTS
ELECTRICAL APPLIANCES

172-186 EMMET STREET
NEWARK, NEW JERSEY

[illegible]

OCTOBER 1929 SALES

1929

Oct. 5	-General Talking Pictures	PA	50	8	240.00	1920.00
	-Calliphone Company	2AP	10	1	40.00	40.00
	- " "	2AP	10	1	40.00	40.00
X 7	-Butterfield Theatre	A	28	1	524.00	524.00
10	-General Talking Pictures	PA	50	10	240.00	2400.00
	- " " "	A	41	12	55.00	660.00
11	-Marks Brothers	A	41	1	62.50	62.50
12	-General Talking Pictures	PA	25A	5	400.00	2000.00
15	- " " "	A	41	10	55.00	550.00
17	- " " "	A	41	32	55.00	1760.00
	-A. A. Emlen	A	21	1	52.65	52.65
18	-Wholesale Radio Service	A	21	1	58.50	58.50
	-General Talking Pictures	A	41	10	55.00	550.00
21	-Platter Cabinet	A	41	2	55.00	110.00
	- " "	PA	51	1	240.00	240.00
19	-General Talking Pictures	A	41	6	55.00	330.00
22	- " " "	A	41	12	55.00	660.00
23	- " " "	A	41	12	55.00	660.00
	- " " "	PA	50	1	240.00	240.00
	- " " "	PA	50	2	240.00	480.00
	-G. Wickizer	D	21	1	65.00	65.00
15	-M. De Vichi	2AP	10	1	40.00	40.00
24	-Perry Smith	2AP	10	1	36.00	36.00
	- " "	D	21	1	58.50	58.50
	-M. De Vichi	D	21	1	65.00	65.00
29	-General Talking Pictures	PA	56	3	292.50	877.50
	-Platter Cabinet	PA	51	1	240.00	240.00
19	-General Talking Pictures	PA	50	2	240.00	480.00
	- " " "	PA	51	9	240.00	2160.00
26	- " " "	PA	51	2	240.00	480.00
	- " " "	PA	56	1	240.00	240.00
29	- " " "	PA	51	3	240.00	720.00
30	- " " "	PA	51	3	240.00	720.00
31	- " " "	PA	51	6	240.00	1440.00
	-Dooleyphone Company	A	37	1	375.00	375.00
+ 5	-Penn. Storage Battery Co.	PA	25A	1	540.00	540.00
				166		21874.65

Less CREDITS

7	-R. B. Scribner	2AP	10	1	36.00	36.00
	- " "	21A		1	57.00	57.00
						93.00
						21781.65

- No 13576 List #30. less 50-10% = 432.00
- No 13377 dot 28. Do = 75.60 119
507.60

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AMERICAN TRANSFORMER COMPANY

TRANSFORMER SPECIALISTS
ELECTRICAL APPLIANCES

173-185 EMMET STREET
NEWARK, NEW JERSEY

Telephone Terrace
4444—4445—4446—4447

NOVEMBER 1929 SALES

Nov.	7	-S. Baraf	A	29	1	720.00	720.
		-S. "	A	33	1	270.00	270.
	5	-General Talking	A	41	12	55.00	660.
	6	- " "	A	41	6	55.00	330.
	1	- " "	PA	51	2	240.00	480.
	2	- " "	PA	51	3	240.00	720.
	4	- " "	PA	51	3	240.00	720.
	9	- " "	PA	51	7	240.00	1680.
	12	- " "	A	41	22	55.00	1210.
	13	- " "	PA	51	6	240.00	1440.
	15	-J. A. Adams	pA	51	1	270.00	270.
		-General Talking	PA	51	4	240.00	960.
	27	- " "	PA	51	4	240.00	960.
	21	- " "	PA	51	2	240.00	480.
		-Dooleyphone Co.	A	25	1	600.00	600.
					75		11500.

Less CREDITS

1	-Wholesale Radio Sup.	D	21	1	57.00	57
3	-Blan	2AP	10	1	36.00	36
18	-Marks Brothers	A	41	1	62.50	62
26	-Powers Cinephone	A	25	1	546.00	546
				4		701

10798

* 32 · No 13576 list 2000 less 50-10% = 388.00
* 1 · Do 13377 list 28.00 Do 12.60
$ 300.60

120

AMERICAN TRANSFORMER COMPANY

TRANSFORMER SPECIALISTS
ELECTRICAL APPLIANCES

172-188 EMMET STREET
NEWARK, NEW JERSEY

Telephone Terrace

DECEMBER 1929 SALES

Dec.	4	-General Talking Pictures	A 41	16	55.00	880.00
		- " " "	PA 51	8	240.00	1920.00
	5	- " " "	A 41	9	55.00	495.00
		-International Research	D 36D	1	500.00	500.00
		- " " "	PA 63	1	139.00	139.00
	10	-General Talking Pictures	A 41	8	55.00	440.00
	11	- " " "	A 41	18	55.00	990.00
	16	- " " "	A 41	18	55.00	990.00
	18	-General Sound Equipment	C 25	2	630.00	1260.00
	12	-General Talking Pictures	PA 51	7	225.00	1575.00
	19	- " " "	A 41	10	55.00	550.00
		- " " "	PA 51	5	225.00	1125.00
	20	- " " "	A 41	10	55.00	550.00
		- " " "	PA 51	5	225.00	1125.00
	24	- " " "	A 41	14	55.00	770.00
		- " " "	PA 51	7	225.00	1575.00
	26	- " " "	A 41	10	55.00	550.00
		- " " "	PA 51	2	225.00	450.00
	28	- " " "	A 41	10	55.00	550.00
		- " " "	PA 51	1	225.00	225.00
	21	-Radio Service Company	A 24	1	65.00	65.00
		- " " "	2AP 2	1	40.00	40.00
	10	-Hammerlund Roberts	2AP 2	1	36.00	36.00
		- " "	D 21	1	58.50	58.50
	16	-Amer. Tel. & Tel. Co	2AP 2	1	40.00	40.00
		- " " "	D 21	1	65.00	65.00
	26	-Deitz c/o Duncans Co	2AP 2	1	40.00	40.00
		- " " "	D 21	1	65.00	65.00
				170		17068.50

Less CREDITS

6	-A. A. Emlen	A 24	1	52.65	52.65
18	-Platter Cabinet	A 41	2	55.00	110.00
	- " "	PA 51	2	240.00	480.00
			5		642.65
					16425.85

35 No. 13576 less 70.00 less 50-10% - 315.00
2 Do 13377 Do 78.00 Do 25.20

$340.20

121

417

1585

#13

STATEMENT

AMERICAN TRANSFORMER COMPANY

MAKERS OF

ELECTRICAL APPLIANCES

174-188 EMMET STREET

NEWARK, N. J. 4/7/30

pd 5/1/30

Radio Corp. of America,
233 Broadway,
New York City.

EXAMINE THIS STATEMENT. WE RENDER ACCOUNTS ON THE FIRST OF EACH MONTH OF ALL ITEMS AS THEY APPEAR ON OUR LEDGER. IF ANY ERRORS OR OMISSIONS PLEASE ADVISE.

CHARGES			CREDITS		
DATE	MEMO.	AMOUNT	DATE	MEMO.	AMOUNT

FIRST OF MONTH

BALANCE $

SUMMARY OF SALES

1930 January Sales Net	$24,733.50	188
February " "	7,730.00	69
March " "	6,769.50	33
		290
	$39,233.00	
Royalties @ 7½	$ 2,942.47	

END OF MONTH

BALANCE $

Total $1101.64 (2 items, estimated)

119

6/18

AMERICAN TRANSFORMER COMPANY

#13

TRANSFORMER SPECIALISTS
ELECTRICAL APPLIANCES

172-180 EMMET STREET
NEWARK, NEW JERSEY

Telephone Terrace
[illegible]

JANUARY 1930 SALES

Jan. 3rd	Gen.Talk.Pict.Corp.	1	PA-51	Amp.	@ $225.		$225.
9th	Radio Shop of Newark	1	PA-66	"	240.		240.
8th	Gen.Talk.Pict.Corp.	10	A-41	"	55.		550.
2nd	" " " "	10	A-41	"	55.		550.
2nd	" " " "	5	PA-51	"	225.		1125.
7th	" " " "	10	A-41	"	55.		550.
7th	" " " "	5	PA-51	"	225.		1125.
10th	" " " "	10	A-41	"	55.		550.
10th	" " " "	5	PA-51	"	225.		1125.
13th	" " " "	16	A-41	"	55.		880.
13th	" " " "	4	PA-51	"	225.		900.
16th	" " " "	5	PA-51	"	225.		1125.
16th	" " " "	10	A-41	"	55.		550.
# 16th	" " " "	14	25-A	"	400.		5600.
14th	" " " "	2	PA-51	"	225.		450.
15th	" " " "	2	PA-51	"	225.		450.
15th	" " " "	5	PA-51	"	225.		1125.
15th	" " " "	10	A-41	"	55.		550.
22nd	" " " "	20	A-41	"	55.		1100.
22nd	" " " "	10	PA-51	"	225.		2250.
28th	" " " "	5	PA-51	"	225.		1125.
28th	" " " "	10	A-41	"	55.		550.
31st	" " " "	5	PA-51	"	225.		1125.
31st	" " " "	10	A-41	"	55.		550.
29th	Genl.Sound Eqdip.Co.	1	PA-55	"	265.		265.
28th	Western Radio Mfg.	1	24A Pr.Box				58.50
30th	Sentry Safety Control	1	2 AP Amp.				40.
		188					24,733.50

* 51 - Transformer Type No 13576 List $20.- Less 50.10% - 486.
# 14 - " " " 13377 - 35 50 176.40

662.40

115-

x Used on PA 50 + PA 51 PA 51 S
" " 25A

1587

AMERICAN TRANSFORMER COMPANY

TRANSFORMER SPECIALISTS
ELECTRICAL APPLIANCES

172-188 EMMET STREET
NEWARK, NEW JERSEY

Telephone Terrace
4444—4445—4459—4460

FEBRUARY 1930 SALES

Feb.	3rd	Gen.Talk.Pict.Comp.	5	PA-51* Amp.	@ $225.	$1125.
	3rd	" " " "	10	A-41 "	55.	550.
	5th	" " " "	5	PA-51 "	225.	1125.
	5th	" " " "	10	A-41 "	55.	550.
	13th	" " " "	5	PA-51 "	225.	1125.
	13th	" " " "	10	A-41 "	55.	550.
	20th	" " " "	5	PA-51 "	225.	1125.
	20th	" " " "	10	A-41 "	55.	550.
	14th	Thos.V.Gould	1	PA-51 "	275.	275.
	28th	DeForest Phonofilm	2	PA-51 "	240.	480.
	7th	T.Southwell	1	245 "	35.	35.
	7th	" "	1	21D Pr.Box	55.	55.
	4th	Wholesale Radio Serv.	1	21D " "	55.	55.
	4th	" " "	1	245 Amp.	35.	35.
	10th	" " "	1	21D Pr.Box	55.	55.
	17th	" " "	1	21D " "	55.	55.
	17th	" " "	1	2-AP-5 Amp.	35.	35.
	1st	Universal Sound Prod.	1	21D Pr.Box	55.	55.
			71			$7835.

LESS CREDIT

1st	M & H.Sporting Goods	1	2 AP-7 Amp.	$ 40.	$ 40.
1st	" " " " "	1	24A Pr.Box	65.	65.
		69			$ 105.

$ 7730.

* 23 Transformer No. 13576 List $20 — Less 50-10% =

116

* Used on PA 50 PA 51 · PA 51-S.

AMERICAN TRANSFORMER COMPANY

TRANSFORMER SPECIALISTS
ELECTRICAL APPLIANCES

172-180 EMMET STREET
NEWARK, NEW JERSEY

Telephone Terrace
4444—4445—4629—4450

MARCH 1930 SALES

Mar. 6th	DeForest Phonofilm	2	25A (25 cy.) Amp. @ $500.		$1000.
5th	" "	1	PA-56 Amp.25cy.@$265.		265.
3rd	Otis Elev.Co.	1	PA-69 "	215.	215.
3rd	Universal Sound Sys.	1	2 AP-2 "	35.	35.
3rd	" " "	1	21D Pr.Box	55.	55.
3rd	Audiphone Corp.	1	A-41 Amp.	62.50	62.50
18th	D.Mackintosh &Son.	1	2 AP-7 "	35.	35.
18th	"	1	21D Pr. Box	55.	55.
24th	"	1	PA-51 Amp.	240.	240.
29th	Gen.Talk.Pict.Corp.	14	PA-51 "	216.	3024.
31st	" " " "	8	PA-51 "	216.	1728.
31st	Universal Sound Sys.	1	Hi Pr. Box	55.	55.
31st	" " "	1	Amplifier	35.	35.
		34			$6804.50

LESS CREDIT

1st	Wholesale Radio Serv.	1	Type P-2 Amp.	$ 35.
		33		
				$6769.50

Net

20 Transformers Type No- 13377 Less 28.00 Less 50-10% 25.20
" " 13576 Do 207.00

$232.20

117

\# 14

STATEMENT

AMERICAN TRANSFORMER COMPANY

MAKERS OF

ELECTRICAL APPLIANCES

174-188 EMMET STREET

NEWARK, N. J.

Radio Corp. of Am.,

233 Broadway,

New York City.

EXAMINE THIS STATEMENT. WE RENDER ACCOUNTS ON THE FIRST OF EACH MONTH OF ALL ITEMS AS THEY APPEAR IN OUR LEDGER. IF ANY ERRORS OR OMISSIONS PLEASE ADVISE.

CHARGES			CREDITS		
DATE	MEMO.	AMOUNT	DATE	MEMO.	AMOUNT

FIRST OF MONTH

BALANCE $

SUMMARY OF SALES

April, 1930 Net Sales	$ 5239.25	58
May " " "	24970.00	244
June " " "	19307.50	179
	$49516.75	481
Royalties @ 7 1/2%	$3713.75	

END OF MONTH

BALANCE $

1736 80

1590

AMERICAN TRANSFORMER COMPANY

#14

TRANSFORMER SPECIALISTS
ELECTRICAL APPLIANCES

172-188 EMMET STREET
NEWARK, NEW JERSEY

Telephone Terrace
4444—4445—4459—4460

APRIL, 1930 SALES

Apr. 9th	J. L. Moffet	1	PA-51 Amplifier	--------	$ 300.00
1st	Genl. Talk. Pict.	2	PA-51 "	--------	452.00
2d	" " "	1	PA-51 "	--------	216.00
1st	" " "	1	PA-70 "	--------	202.50
14th	Movox Corp.	2	PA-52 "	--------	125.00
28th	Genl. Talk. Pict.	30	A-41 "	--------	1500.00
28th	" " "	5	PA-51 "	--------	1125.00
30th	Arcturus Radio	1	A-41 "	--------	56.25
	" "	1	PA-51 "	--------	270.00
	Movox Corp.	2	A-52 "	--------	112.50
	Genl. Talk. Pict.	10	A-41 "	--------	500.00
	" " "	2	PA-51S "	--------	400.00
					$5239.25

18

17 Transformers Type No. 13576 — 108.00
.110

AMERICAN TRANSFORMER COMPANY

TRANSFORMER SPECIALISTS
ELECTRICAL APPLIANCES

172-186 EMMET STREET
NEWARK, NEW JERSEY

Telephone Terrace

MAY 1930 SALES

May 1st	- Genl. Talk. Pict.	- 5	A-41	Amplifiers ------	$ 250.00
	- " " "	- 3	PA-518	" ------	600.00
	- " " "	- 3	PA-518	" ------	600.00
	- " " "	- 5	A-41	" ------	250.00
5th	- " " "	- 2	PA-518	" ------	400.00
	- " " "	-15	A-41	" ------	750.00
6th	- " " "	-10	A-41	" ------	500.00
	- " " "	- 3	PA-518	" ------	600.00
7th	- " " "	- 2	PA-518	" ------	400.00
9th	- " " "	-15	A-41	" ------	750.00
10th	- " " "	- 5	A-41	" ------	250.00
10th	- " " "	- 1	PA-518	" ------	200.00
10th	- " " "	- 7	PA-518	" ------	1400.00
12th	- " " "	- 2	PA-518	" ------	400.00
	- E. M. Zelony	- 1	25-A	" ------	540.00
15th	- Genl. Talk. Pict.	- 5	A-41	" ------	250.00
	- " " "	- 1	PA-568	" ------	200.00
	- " " "	- 5	A-41	" ------	250.00
	- " " "	- 8	A-41	" ------	400.00
17th	- " " "	- 6	A-41	" ------	300.00
	- " " "	- 4	PA-518	" ------	800.00
14th	- " " "	- 3	PA-518	" ------	600.00
15th	- " " "	- 2	PA-518	" ------	400.00
16th	- " " "	- 3	PA-518	" ------	600.00
17th	- " " "	- 2	PA-518	" ------	400.00
16th	- J. V. Moffett	- 1	25A	" ------	600.00
	- E. M. Zelony	- 1	PA-51	" ------	270.00
19th	- Genl. Talk. Pict.	- 8	A-41	" ------	400.00
	- " " "	- 1	PA-51	" ------	225.00
	- " " "	- 2	PA-518	" ------	400.00
13th	- J. J. Thomas	- 1	PA-89	" ------	195.00
20th	- Genl. Talk. Pict.	- 2	PA-518	" ------	400.00
	- " " "	- 1	PA-51	" ------	225.00
	- " " "	- 4	A-41	" ------	200.00
21st	- " " "	-12	A-41	" ------	600.00
	- " " "	- 1	PA-518	" ------	200.00
24th	- " " "	- 8	A-41	" ------	400.00
21st	- " " "	- 2	PA-51	" ------	450.00
	- " " "	- 1	PA-518	" ------	200.00
22d	- " " "	- 2	PA-51	" ------	450.00
24th	- " " "	- 2	PA-518	" ------	400.00

111

AMERICAN TRANSFORMER COMPANY

TRANSFORMER SPECIALISTS
ELECTRICAL APPLIANCES

172-186 EMMET STREET
NEWARK, NEW JERSEY

Telephone Terrace
[illegible]

MAY 1930 SALES CONT'D.

May 22d -	Genl. Talk. Pict.	- 1 PA-518	Amplifiers	------	$ 200.00
23d -	" " "	- 3 PA-518	"	------	600.00
24th-	" " "	- 1 PA-518	"	------	200.00
22d -	" " "	- 8 A-41	"	------	400.00
23d -	" " "	- 9 A-41	"	------	450.00
27th-	DeForest Phonofilm	- 2 PA-50	"	------	480.00
26th-	Genl. Talk. Pict.	- 4 A-41	"	------	200.00
-	" " "	- 2 PA-518	"	------	400.00
27th-	" " "	-10 A-41	"	------	500.00
-	" " "	- 1 PA-58	"	------	282.50
	" " "	- 2 A-41	"	------	100.00
-	" " "	- 1 PA-518	"	------	200.00
-	" " "	- 1 PA-518	"	------	200.00
28th-	" " "	- 1 25-A	"	------	540.00
29th-	" " "	- 2 A-41	"	------	100.00
-	" " "	- 2 A-41	"	------	100.00
-	" " "	- 2 A-41	"	------	100.00
-	" " "	- 1 PA-58	"	------	282.50
-	" " "	- 4 PA-58	"	------	1130.00
-	" " "	- 8 A-41	"	------	400.00
-	" " "	- 1 PA-518	"	------	200.00
-	" " "	- 1 PA-518	"	------	200.00
		144			$24970.00

					Net
Transformers	Type No.	13576	List # 20	Less 50-10%	585.00
Do	Do	13377	List 78	Do	37.80
					$ 622.80

112

1593

AMERICAN TRANSFORMER COMPANY

TRANSFORMER SPECIALISTS
ELECTRICAL APPLIANCES

173-189 EMMET STREET
NEWARK, NEW JERSEY

Telephone Terrace
[illegible]

JUNE 1930 SALES

June 2d	- Genl. Talk. Pict.	- 10 A-41 Amplifiers	------ $ 500.00
-	" " "	- 5 PA-518 "	------ 1000.00
4th	- " " "	- 8 A-41 "	------ 400.00
-	" " "	- 6 A-41 "	------ 300.00
-	" " "	- 4 PA-518 "	------ 800.00
10th	- " " "	- 2 PA-518 "	------ 400.00
14th	- " " "	- 5 25-A "	------ 1200.00
13th	- " " "	- 7 25-A "	------ 2800.00
16th	- " " "	- 20 A-41 "	------ 1000.00
13th	- " " "	- 10 A-41 "	------ 500.00
16th	- " " "	- 7 PA-51 "	------ 1575.00
-	" " "	- 3 PA-51 "	------ 675.00
17th	- " " "	- 1 PA-518 "	------ 200.00
-	" " "	- 2 PA-518 "	------ 400.00
-	" " "	- 2 PA-51 "	------ 450.00
-	" " "	- 10 A-41 "	------ 500.00
18th	- DeForest Phonofilm	- 2 PA-50 "	------ 480.00
19th	- Genl. Talk. Pict.	- 3 PA-518 "	------ 600.00
-	" " "	- 6 A-41 "	------ 300.00
25th	- " " "	- 10 A-41 "	------ 500.00
-	" " "	- 4 A-41 "	------ 200.00
26th	- " " "	- 10 A-41 "	------ 500.00
-	" " "	- 6 PA-51 "	------ 1290.00
27th	- " " "	- 10 A-41 "	------ 500.00
30th	- " " "	- 5 PA-51 "	------ 1075.00
-	" " "	- 10 A-41 "	------ 500.00
-	" " "	- 12 A-41 "	------ 600.00
	- Good-All Elec.	- 1 A-82 "	------ 62.50
			$19307.50

177

* 112 Transformers Type No. 13576 List 30 Less 50-10% -
* 10 - Do Do - 13377 Do 28 Do

115

STATEMENT

AMERICAN TRANSFORMER COMPANY

MAKERS OF

ELECTRICAL APPLIANCES

174-188 EMMET STREET

NEWARK, N. J.

Radio Corp. of Am.,

233 Broadway,

New York City.

EXAMINE THIS STATEMENT. WE RENDER ACCOUNTS ON THE FIRST OF EACH MONTH OF ALL ITEMS AS THEY APPEAR IN OUR LEDGER. IF ANY ERRORS OR OMISSIONS PLEASE ADVISE.

CHARGES			CREDITS		
DATE	MEMO.	AMOUNT	DATE	MEMO.	AMOUNT

FIRST OF MONTH

BALANCE $

SUMMARY OF SALES

July, 1930 Net Sales - $19107.50

August " " - 26408.50

September " " - 34734.50

$80250.50

Royalties @ 7 1/2% $6018.79

END OF MONTH

BALANCE $

Total Sales to be deducted $2115.00

104

1595

AMERICAN TRANSFORMER COMPANY

TRANSFORMER SPECIALISTS
ELECTRICAL APPLIANCES

172-188 EMMET STREET
NEWARK, NEW JERSEY

Telephone Terrace
4444—4445—4446—4448

#1

JULY 1930 SALES

July	8th	- Genl. Talk. Pictures	- 3-PA51	Amplifiers	-----	$ 645.0
	2d	- " " "	- 8-A41	"	-----	400.0
	10th	- " " "	- 5-PA51	"	-----	1075.0
	12th	- " " "	-10-PA51	"	-----	2150.0
	14th	- " " "	-30-A41	"	-----	1500.0
	15th	- " " "	- 3-PA51	"	-----	645.0
	15th	- " " "	-10-A41	"	-----	500.0
	16th	- " " "	- 6-A41	"	-----	300.0
	17th	- " " "	- 5-PA51	"	-----	1075.0
	18th	- " " "	- 4-A41	"	-----	200.0
	19th	- " " "	- 2-PA51	"	-----	430.0
	21st	- " " "	- 1-A62	"	-----	475.0
	21st	- " " "	- 4-PA51	"	-----	860.0
	22d	- " " "	- 1-PA51	"	-----	215.0
	23d	- " " "	-20-A41	"	-----	1000.0
	22d	- " " "	- 3-PA51	"	-----	645.0
	25th	- " " "	- 4-A41	"	-----	200.0
	24th	- " " "	- 4-PA51	"	-----	860.0
	26th	- Trans Lux Daylight Pic	1-A52	"	-----	62.5
	25th	- Genl. Talk. Pictures	-22-A41	"	-----	1100.0
	28th	- " " "	-10-A41	"	-----	500.0
	25th	- " " "	- 2-PA51	"	-----	430.0
	26th	- " " "	- 3-PA51	"	-----	645.0
	28th	- " " "	- 3-PA51	"	-----	645.0
	29th	- " " "	- 3-PA51	"	-----	645.0
		- " " "	- 3-PA51	"	-----	645.0
	30th	- " " "	- 8-A41	"	-----	400.0
	31st	- " " "	- 3-PA51	"	-----	645.0
		- " " "	- 4-PA51	"	-----	860.0
						$19107.[illegible]

N

* 58 Transformers Tiffin No. 13576 - List " - Less 50-10% $ 52

AMERICAN TRANSFORMER COMPANY

TRANSFORMER SPECIALTIES
ELECTRICAL APPLIANCES

178-186 EMMET STREET
NEWARK, NEW JERSEY

Telephone, Terrace

AUGUST 1930 SALES

Aug. 5th	- Vaughan Elec.	- 1-21D Power Box	----------	$ 58.50
	- Genl. Talk. Pictures	- 1-PA82 Amplifier	-----	940.00
6th	- " " "	- 1-PA51 "	-----	215.00
7th	- " " "	- 3-PA51 "	-----	645.00
8th	- " " "	- 2-PA51 "	-----	430.00
	- Wilmington Elec. Spec.	1-PA51 "	-----	300.00
	- C. H. Deane	1-PA51 "	-----	300.00
11th	- Genl. Talk. Pictures	-10-A41 "	-----	500.00
13th	- " " "	-10-A41 "	-----	500.00
	- " " "	- 4-PA51 "	-----	860.00
11th	- " " "	- 1-PA51 "	-----	215.00
12th	- " " "	- 6-P51 "	-----	1290.00
14th	- " " "	- 5-PA51 "	-----	1075.00
15th	- " " "	-22-A41 "	-----	1100.00
	- " " "	- 3-PA51 "	-----	645.00
16th	- " " "	- 6-PA51 "	-----	1290.00
18th	- " " "	- 5-PA51 "	-----	1075.00
19th	- " " "	- 6-PA51 "	-----	1290.00
20th	- " " "	- 5-PA51 "	-----	1075.00
21st	- " " "	-18-A-41 "	-----	900.00
	- " " "	- 3-PA51 "	-----	645.00
25th	- " " "	- 9-PA51 "	-----	1935.00
23d	- " " "	- 4-PA51 "	-----	860.00
25th	- " " "	- 6-PA-51 "	-----	1290.00
26th	- " " "	- 1-PA51 "	-----	215.00
	- " " "	- 8-A41 "	-----	400.00
27th	- " " "	-12-A41 "	-----	600.00
	- " " "	- 4-PA51 "	-----	860.00
28th	- " " "	-10-A41 "	-----	500.00
	- " " "	- 4-PA51 "	-----	860.00
29th	- " " "	-15-A41 "	-----	750.00
	- " " "	- 6-PA51 "	-----	1290.00
30th	- " " "	- 8-PA51 "	-----	1720.00
31st	- " " "	- 2-PA51 "	-----	430.00
				$26408.50

96 - Transformers Type No 13576 - Less 20% Less 50-10% = 86.40 Net

1597

AMERICAN TRANSFORMER COMPANY

TRANSFORMER SPECIALISTS
ELECTRICAL APPLIANCES

172-186 EMMET STREET
NEWARK, NEW JERSEY

Telephone Terrace
[illegible]

SEPTEMBER 1930 SALES

Sept. 3d -	Genl. Talk. Pictures-	15 A-41	Amplifiers	------	$ 650.00
3d -	" " " -	10 A-41	"	------	500.00
8th-	" " " -	22 A-41	"	------	1100.00
10th-	" " " -	15 A-41	"	------	750.00
13th-	Vitaphone Corp. -	1-P-77	Rectifier	------	200.00
13th-	Genl. Sound Equip. -	2-250	Amplifier	------	1000.00
15th-	" " -	2-250		------	1000.00
16th-	DeForest Phonofilm -	2-PA51	"	------	480.00
11th-	Genl. Talk. Pict. -	20-A41	"	------	1000.00
12th-	" " " -	20-A41	"	------	1000.00
13th-	" " " -	20-A41	"	------	1000.00
15th-	" " " -	4-PA51.	"	------	1075.00
16th-	" " " -	20-A41	"	------	1000.00
16th-	" " " -	5-PA51	"	------	1075.00
18th-	WEAR Rad. Corp. -	1-P77	Rectifier	------	200.00
18th-	Sta. WMAL -	1-P77	"	------	200.00
19th-	Rad. Sta. WBZA -	1-P77	"	------	200.00
17th-	Wired Radio -	1-P77	"	------	200.00
-	Genl. Talk. Pict. -	5-A41	Amplifiers	------	250.00
-	" " " -	5-PA51	"	------	1075.00
19th-	" " " -	6-PA51	"	------	1290.00
17th-	" " " -	5-A41	"	------	250.00
18th-	" " " -	10-A41	"	------	500.00
17th-	Penn Bdcstg. Co. -	2-P77	Rectifiers	------	400.00
19th-	Genl. Talk. Pict. -	5 PA51	Amplifiers	------	1075.00
-	" " " -	10 A41	Amplifiers	------	500.00
20th-	" " " -	10 A41	"	------	500.00
-	" " " -	5 PA51	"	------	1075.00
22d -	" " " -	10 A41	"	------	500.00
-	" " " -	5 PA51	"	------	1075.00
19th-	" " " -	2 PA56	"	------	480.00
23d -	" " " -	20 A41	"	------	1000.00
-	" " " -	5 PA51	"	------	1075.00
24th-	" " " -	10 A41	"	------	500.00
-	" " " -	5 PA51	"	------	1075.00
26th-	" " " -	10 A41	"	------	500.00
-	" " " -	5 PA51	"	------	1075.00
27th-	Film Sound Corp. -	1 PA96	"	------	97.75
27th-	Genl. Talk. Pictures-	5 A41	"	------	250.00
29th-	" " " -	5 PA51	"	------	1075.00
-	" " " -	10 A41	"	------	500.00

\# 102 Transformers Type No. 13576 List 20. Less 50. 10% Net 662.00
\# 5 Do Do 13577 " " 28. Do 63.00
107 \# 779.00

AMERICAN TRANSFORMER COMPANY

TRANSFORMER SPECIALISTS
ELECTRICAL APPLIANCES

172-188 EMMET STREET
NEWARK, NEW JERSEY

Telephone Terrace
4466—4467—4468—4469

SEPTEMBER 1930 SALES CONT'D.

Sept. 27th-	Genl. Talk. Pictures	- 5-A41	Amplifiers------	$ 250.00
-	" " "	- 5-PA51	" ------	1075.00
27th-	" " "	- 1-P32	" ------	90.00
-	" " "	- 1-A36	" ------	127.00
29th-	" " "	- 1-P32	" ------	90.00
-	" " "	- 1-A36	" ------	127.00
✓-	M & H Sptg. Goods	- 1-PA86	" ------	87.75
-	Genl. Talk. Pictures	- 5-PA51	" ------	1075.00
30th-	" " "	- 5-PA51	" ------	1075.00
29th-	" " "	-10-A41	" ------	470.00
30th-	" " "	-25-A41	" ------	1175.00
25th-	DeForest Phonofilm	- 2-PA51	" ------	430.00
				$34859.50

Less Credits due

Sept. 2d - Genl. Talk. Pict.
1-A62 billed 1/9 @
$475. should have
been $350.00 ------------$125.00 125.00

$34734.50

108

(13)

1599

#16

STATEMENT

AMERICAN TRANSFORMER COMPANY

MAKERS OF

ELECTRICAL APPLIANCES

174-188 EMMET STREET

NEWARK, N. J.

Radio Corp. of Am.,

233 Broadway,

New York City.

EXAMINE THIS STATEMENT. WE RENDER ACCOUNTS ON THE FIRST OF EACH MONTH OF ALL ITEMS AS THEY APPEAR IN OUR LEDGER. IF ANY ERRORS OR OMISSIONS PLEASE ADVISE.

CHARGES			CREDITS		
DATE	MEMO.	AMOUNT	DATE	MEMO.	AMOUNT

FIRST OF MONTH

BALANCE $

SUMMARY OF SALES:

October, 1930 Net Sales - $33680.00

November " - 13046.00

December " - 12641.10

$59367.10

Royalty @ 7 1/2% = $4452.55

$ 59367.10
+ 513.00
59880.10
- 1764.00
$58116.10

Total sales to be deducted
$1764.00

95-

END OF MONTH

BALANCE $

AMERICAN TRANSFORMER COMPANY

Transformer Specialists — *Electrical Manufacturers*

#16

178 EMMET ST. — NEWARK, N. J.

Telephone Tilmage 3-4000

OCTOBER SALES.

*****

Oct. 3d -	Bakelite Co. -	1		Special Amplifier		---------$	85.00
Oct. 1st-	Genl. Talking Pictures	- 5	Type	PA-51	Amp.	--	1025.00
		10	Type	A-41	Amp.	--	470.00
Oct. 3d -	" " "	-20	Type	PA-51	Amp.	--	2050.00
		20	"	A-41	"	--	940.00
4th-	" " "	- 4	"	PA-51	"	--	820.00
		8	"	A-41	"	---	376.00
3d -	" " "	- 2	"	25A	"	--	750.00
1st-	Northwest Broadcast	- 2	"	P-77 Sup.Units			400.00
1st-	Sta. W. G. B.S.	- 1	"	P-77 Rect.		--	200.00
6th-	Genl. Talk. Pict.	- 2	"	PA-51	Amp.	--	410.00
		- 4	"	A-41	"	--	188.00
7th-	" " "	- 5	"	PA-51	"	--	1025.00
		10	"	A-41	"	--	470.00
10th-	Genl. Sound Corp.	- 2	"	25C	"	--	1000.00
8th-	" Talking Pict.	- 5	"	PA-51	"	--	1025.00
		10	"	A-41	"	--	470.00
9th-	" " "	- 6	"	PA-51	"	--	1230.00
		-12	"	A-41	"	--	564.00
10th-	" " "	- 5	"	PA-51	"	--	1025.00
		10	"	A-41	"	--	470.00
11th-	" " "	- 4	"	PA-51	"	--	820.00
		8	"	A-41	"	--	376.00
13th-	" " "	- 4	"	PA-51	"	--	820.00
		8	"	A-41	"	--	376.00
15th-	Columbia Bdcstg.	- 1	"	PA-51	"	--	270.00
	- " "	- 1	"	25A	"	--	540.00 x 540 -
14th -	Genl. Talk. Pict.	- 3	"	PA-53	"	--	675.00
		6	"	A-41	"	--	282.00
	- " " "	- 3	"	PA-41	"	--	615.00
		6	"	A-41	"	--	282.00
15th-	" " "	- 5	"	PA-51	"	--	1025.00
		13	"	A-41	"	--	611.00
17th-	" " "	- 8	"	PA-51	"	--	1640.00
		18	"	A-41	"	--	846.00
25th-	" " "	- 3	"	PA-51	"	--	615.00
20th	- " " "	- 5	"	PA-51	"	--	1025.00
		15	"	A-41	"	--	705.00
21st-	" " "	- 4	"	PA-51	"	--	820.00
		12	"	A-41	"	--	564.00
22d	" " "	8	"	A-41	"	--	376.00
23d	" " "	21	"	A-41	"	--	987.00
24th	" " "	7	"	A-41	"	--	329.00

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1601

AMERICAN TRANSFORMER COMPANY

Transformer Specialists AMER TRAN *Electrical Manufacturers*

178 EMMET ST. NEWARK, N. J.

Telephone TErrace 3-4444

. OCT. #2

Oct. 27th	- Genl. Talk. Pict.	- 3 ~~10~~	Type PA5 ~~Type A-41~~	Amp	-----------	$ 615.00
28th	- " " "	- 10	Type A-41	"	-----------	470.00
29th	- " " "	- 8	" A-41	"	-----------	376.00
		4	" PA-51	"	-----------	820.00
30th	- " " "	- 3	" PA-51	"	-----------	615.00
		2	" A-41	"	-----------	94.00
25th	- E. M. Zelony	- 4	" PA-86	"	-----------	351.00
31st	- Genl. Talk. Pict.	- 10	" PA-51	"	-----------	2050.00
	- Hoovenir Corp.	- 1	" PA-84	"	-----------	80.00
						$35045.00

LESS CREDITS:

Oct. 3d	- E. M. Zelony	- 1	" 25A	"	-----$540.	
	" " "	- 1	" PA-51	"	----- 270.	
	" " "	- 1	" 25A	"	----- 540.	
7th	- Genl. Talk. Pict.	- 5	" A-41	"		
			billed @ $50.Ea			
			should be 47.		--- 15.	1365.00
						$33680.00

7 1/2% Royalty on $33680.00 = $2526.00

* 93. Transformer Type No. 13576 List 20. Less 50 10% = 8
* 5 - Do Do 13377 List 28 Do

Go

97

52

1

AMERICAN TRANSFORMER COMPANY

Transformer Specialists — *Electrical Manufacturers*
178 EMMET ST. NEWARK, N. J.
Telephone TErrace 3-4444

NOVEMBER SALES.

****

Nov. 1st	- Genl. Talk. Pict.	2	Type	PA-51	Amp.	$ 410.00
3d	- " " "	1	"	PA-51	"	205.00
4th	- " " "	7	"	PA-51	"	1435.00
5th	- " " "	4	"	PA-51	"	820.00
6th	- " " "	7	"	PA-51	"	1485.00 1435.
7th	- " " "	6	"	PA-51	"	1230.00
11th	- " " "	1	"	P-56	"	840.00
4th		10	"	A-41	"	470.00
5th	- " " "	10	"	A-41	"	470.00
11th	- E. M. Zelony	1	"	PA-86	"	87.75
11th	- E. M. Zelony	1	"	PA-86	"	87.75
14th	- Voisophone Co.	1	"	A-55	"	78.00
21st	- Linorophone Co.	1	"	PA-86	"	87.75
20th	- Genl. Sound Equip.	1	"	250	"	500.00
25th	- Genl. Talk. Pict.	10	"	PA-51	"	2050.00
		10	"	A-41	"	470.00
28th	- " " "	5	"	PA-51	"	1025.00
2.th	- " " "	10	"	PA-51	"	2050.00
		20	"	A-41	"	940.00
						$14091.25

LESS CREDITS:

Nov. 1st	- Trans-Lux Daylight	2	"	A-52	-- $125.00	
5th	- Genl. Talk. Pict.	1	"	PEC Amp.	-- 50.00	
13th	- M. & H. Sptg. Goodsl		"	PA-86"	-- 87.75	
	- Genl. Talk. Pict.	1	"	PA-70:	-- 202.50	465.25
						$13626.00
1st	- Wired Radio	1	"	P-77 Rec.	-- 200.00	
	- Hoovenir Corp.	1	"	PA-84Amp.	-- 80.00	
	- C. E. Deane	1	"	PA-51 "	-- 300.00	580.00
						$13046.00

7 1/2% Royalty ib $13046.00 = $978.45

Transformers Type No. 13376 List 20.00 less 50-10% = 468.00
Do 50 13377 do 28.00 Do = 12.60

$ 480.60

5

AMERICAN TRANSFORMER COMPANY

Transformer Specialists · *Electrical Manufacturers*
178 EMMET ST. NEWARK, N. J.
Telephone [illegible] 3-4444

DECEMBER SALES.

****

Dec. 2d -	Genl. Talk. Pict. -	1	Type	PA-86 Amp.		$ 240.00
1st-	" " " -	4	"	PA-51	"	820.00
		8	"	A-41	"	376.00
2d -	" " " -	6	"	PA-51	"	1230.00
		12	"	A-41	"	564.00
3d -	" " " -	5	"	PA-51	"	1025.00
		10	"	A-41	"	470.00
4th-	" " " -	2	"	A-36	"	254.00
		2	"	P-32	"	180.00
2d -	Knickerbocker Bdcst	2	"	PA-86	"	162.00
8th-	M. & H. Sptg. Goods	1	"	PA-86	"	78.75
3d -	George Co.	1	"	PA-86	"	97.50
4th-	Genl. Talk. Pict.	5	"	PA-51	"	1025.00
		10	"	A-41	" unmounted	456.00
5th-	" " "	5	"	PA-51	"	1025.00
		10	"	A-41	" unmounted	456.00
18th-	Linorophone Co.	1	"	PA-86	"	97.50
-	Genl. Talk. Pict.	5	"	PA-51	"	1025.00
		10	"	A-41	"	470.00
19th-	" " "	4	"	PA-51	"	820.00
		8	"	A-41	"	376.00
16th-	Asso. Rad. Buyers	1	"	PA-84	"	72.00
19th -	W. G. Preddy	1	"	PA-86	"	87.75
20th-	Genl. Talk. Pict.	3	"	PA-51	"	615.00
		6	"	A-41	"	282.00
27th-	M. & H. Sptg. Goods	1	"	PA-85	"	82.00
22d -	W. G. Preddy	1	"	PA-86	"	87.75
31st-	American Sales Co.	1	"	A-36	"	156.00
		1	"	P-32		109.20
-		1	"	PA-30		163.80
-	" "	1	"	A-36		156.00
-	" "	1	"	P-32		109.20
-	" "	1	"	PA-39		163.80
-	" "	1	"	A-67		176.80
-	" "	1	"	P-63		124.80
-	Knickerbocker Bdct.	1	"	P-91 & P-92		325.00
						$13958.[illegible]

LESS CREDITS:

Dec. 15th	N. J. Bdcstg.	1	"	PA-66 Amp.	$ 480.00	
	Penn. Bdcstg	1	"	P-77 Rec.	200.00	
	Genl. Bdcstg.	1	"	P-77 "	200.00	
	Vitaphone Co.	1	"	P-77 "	200.00	
22-	Voleophone Co.	1	"	A-53 Amp.	78.00	
-	United Sound Eng.	1	"	PA-84 "	72.00	
-	Fox Elec. Mfg.	1	"	PA-86 "	87.75	1317.75
						$12641.10

7 1/2% Royalty on $12641.10 = $948.08

#37 Transformer Type No 13576 - List 70 - Less 50-10% = $333.00

4 Do Do 13577 - Do 38 - Do 50.40

383.40

99

1604

#17

AMERICAN TRANSFORMER COMPANY

Transformer Specialists — *Electrical Manufacturers*

178 EMMET ST. — NEWARK, N. J.

Telephone TIlman 3-6666

ROYALTIES FOR JANUARY 1931

Jan. 5	Voisophone	P-32 Panel	$128.00
5	"	A-36 "	150.00
5	"	PA-39 "	189.00
9	Larus & Bro.	P-77 Rectifier	200.00
12	Wired Radio	P-77 Panel	200.00
13	C. W. Mitchell	PA-86 Amplifier	87.75
8	Sound on Service	3-A-55 Amp. @ $78. Ea.	234.00
14	W. G. Preddy	PA-86 Amp.	87.75
16	W. Va. Univ.	PA-86 Amp.	97.50
24	Kunsky-Trendle	P-77	200.00
22	M & H Sptg. Goods	PA-85 Amp.	81.00
	Sta. W. G. N.	P-77	200.00
14	Ad. Auriema	PA-86	78.00
27	Sound on Service	PA-86	87.75
30	Genl. Talk. Pict.	18-PA-81 205. Ea.	3690.00
	" " "	36 A-41 47. "	1692.00
23	C.C. Langevin	PA-86 Amp.	87.75
29	M&H Sptg. Gds,	PA-85 Amp.	81.00
26	WIP-WFAN Bdcstg	P-77 Rec.	200.00
30	Cameradio	P-77 Rec.	200.00
23	Sta. WOBU	P-77 Rec.	200.00
30	W. G. Preddy	PA-86 Amp.	87.75
			[illegible].25

less 12.60

less 162.00

Less Credits:

Jan. 28	Presto Mach.	2AP-7 Amp.	$ 38.	
28	Davenport E.	PA-84 Amp.	97.50	
30	Manus Elec.	H-PA-86 Amp,	195.00	
31	Ohio Music	A-55 Amp.	78.00	
31	LinorophoneCo	A-55 Amp.	78.00	484.50
				[illegible]
	Less Credit below			174.60

7 1/2% of $[illegible].15 = $[illegible].11 $[illegible].15

Credit as above-

1 - 13377A --- $12.60

18 - 13376A --- 162.00

\# $174.60 These transformers were included in price of amplifiers as marked above and should not have been.

88

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AMERICAN TRANSFORMER COMPANY

Transformer Specialists — Electrical Manufacturers

178 EMMET ST. — NEWARK, N. J.

Telephone TAlmage 3-6666

ROYALTIES FOR FEBRUARY 1931.

Feb 1	- Sound on Service	- S-53	---------------------$	78.00
6	- W. G. Preddy	- PA-86 Amp.	------------------	87.75
5	- E. Markel	- PA-86	------------------	117.00
	- E. Markel	- 2 A-53 @ $105. Ea.	--------	210.00
10	- E. Markel			
		- 2 A-72 @ $105. Ea.	--------	210.00
x 14	- Genl. Talk.	- 2 A-36 @ $127. Ea.	--------	254.00
x	- " "	- 2 P-52 @ 90. Ea.	--------	180.00
x 13	- Sta. W. O. B. U.	- P77A Panel	-------------	200.00
x 16	- Suffolk Elec.	- P-77	------------------	200.00
18	- Linarophone Co.	- PA-86	------------------	97.50
21	- Elec. Supp. Corp	- PA-86	------------------	87.75
18	- Hughes-Peters	- PA-86	------------------	87.75
	- " "	- PA-84	------------------	[illegible].00
x 24	- Sta. W.B.E.N.	- P-77	------------------	210.00
x 19	- Genl. Talk. Pict.	- 3 - A-36 @ $127. Ea.	------	381.00
x	- " " "	- 3 - P-52 @ 90. "	------	270.00
x 25	- Sta. WMAL	- P-77	------------------	200.00
	- Bacon Elec.	- PA-86	------------------	83.25
				$3026.00

Less Credits:

20	- E. Markel	- A-72 Amp.	---------$105.	
24	- M & M Sptg.	- PA-86	------------ 78.75	
				183.75
				$2842.25
		Less Credit as below	--------	25.20
				$2817.05

7 1/2% of $2817.05 = $211.28

Less 2-13377A Transformers $25.20 in above price of amplifier and should not be so have deducted.

Mill 2.5.20

89

7

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AMERICAN TRANSFORMER COMPANY

Transformer Specialists — *Electrical Manufacturers*

178 EMMET ST. — NEWARK, N. J.

Telephone Tilmore 3-4444

ROYALTIES FOR MARCH 1931

	Mar. 1	- Ad Auriema - PA-86 Amp.		$ 78.00
		- Elec. Supp.- PA-86 "		87.75
x	2	- N. J. Rad. - PA-84		99.90
	6	- Radio Supp.- 2- PA86 Amp. @ $87.75 Ea.		175.50
	11	- Universal Sd. & Serv. 1PA-84		72.00
		- " " " 1PA-85		83.25
	10	- Natl. Union Radio PA-84		80.00
	19	- Universal Sd. & Serv. PA-86		87.75
x	21	- Universal Amp. Co.	PA-84	412.50
x		"	A-80	450.00
x		"	P-63	138.75
x		"	PA-89	195.00
x	18	- Knickerbocker	A-87 Special	262.50
x		Bdcstg.	2 - Type A 80B @ $220. Ea.	440.00
x		"	2 - Type P-102 Panels @ $15.	30.00
x		"	1 - " P-77	200.00
	18	- W. G. Preddy PA-86		87.75
x	25	- Island Radio A-87		180.00
x		- " " P-63		138.75
	20	- W. G. Preddy PA-86		87.75
	23	- W. G. Preddy PA-86		87.75
x	21	- Universal Amp. PA-86		87.75
	17	- Hammarlund Roberts PA-86		87.75
x	26	- Bamberger Bdcstg. A-80		225.00
x		- " A-87		180.00
x		- " P-63		138.75
x	31	- Rad. Air Serv. A-80		225.00
x		- " " " A-87		180.00
x		- " " " P-63		138.75
x		- " " " PA-84		412.50
x		- " " " PA-86		87.75
x		- " " " PA-84		72.00
x		- " " " 10-P-101 @ $25.20 Ea.		252.00
		- Hughes-Peters PA-86		87.75
				$5649.90

Less Credits:

31	- AmerTran Sales A-87	$176.80		
	" " P-63	124.80		
16	- M & H Sptg. PA-85	81.00	382.60	
			$5267.30	

7 1/2% of $5267.30 = $395.05

Jany	7628.15	572.11
Feby	2817.05	211.28
	$ 15,712.50	$ 1178.44

90

1607

Transformer Specialists

THomas 2-6644

Amp[lifier] Equip[ment]

AMERICAN TRANSFORMER COMPANY

178 Emmet St. Newark, N. J.

October 28, 1931

Radio Corporation of America
51st St. & Lexington Ave.
New York City

Gentlemen:

We are enclosing statements of sales made by us under our license for the second quarter of this year and also for the month of July, with these we are enclosing our check for $1266.69 for the month of July and one for $1180.93 for the second quarter of this year.

We are enclosing a check for $1178.44 covering royalties for the first part of this year and a check for $4452.53 for royalties for the fourth quarter of 1930.

The list of sales for these last two periods you already have.

A check for the royalties listed on your schedule A attached to your letter of December 18, 1929 will go forward to you very shortly.

Very truly yours,

CFL:MB

AMERICAN TRANSFORMER COMPANY

Chas. F. Loughead

C. F. LOUGHEAD
PRESIDENT

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AMERICAN TRANSFORMER COMPANY

Transformer Specialists — *Electrical Manufacturers*

178 EMMET ST., NEWARK, N. J.

Telephone Humboldt 3-4444

#18

ROYALTIES FOR APRIL, 1931

3	Cross Mfg. Co.	PA-86	$ 87.50
4	Motion Picture Theatre	A-36	150.00
	" " "	P-32	108.75
3	Radio Air Serv.	A-36	150.00
	" "	P-32	108.75
	" "	PA-39	195.00
2	F. A. Boykin	PA-84	48.00
	Silman Distrib. Co.	PA-86	87.75
4	Universal Sd. & Serv. Co	A-67	180.00
	" " " "	P-63	138.75
2	Warner Bros,	A-72	45.00
	" "	PA-86	97.50
4	Wired Radio, Inc	P-77	200.00
10	J. K. Elderkin	PA-84	80.00
7	J. K. Elderkin	PA-86	97.50
6	Bamberger Bdcstg.	A-36	150.00
	" "	P-32	108.75
	" "	PA-39	195.00
9	Universal Sd. & Serv.	2-PA-84 @ 72. Ea.	144.00
	" "	PA-86	87.75
10	Western Radio Eng.	P-77	292.50
7	Racon Elec. Co.	PA-85	65.25
15	J. N. D. Greathead	PA-85	65.25
	Royal Bdcstg. Studio	A-36	150.00
	" "	P-32	108.75
	" "	PA-39	195.00
17	Elec. Supp. Corp.	PA-86	81.00
15	" "	PA-86	87.75
	" "	A-89 — 2 @ $40.50 Ea.	81.00
	" "	A-89	40.50
16	Graybar Elec.	P-77	180.00
17	C. M. Bowman	PA-85	108.60
21	Head of Lakes Bdcstg.	PA-86	97.50
14	Kruse Radio	PA-86	97.50
20	Radio Air Serv.	2 Spec. 2AP Amp. @ $46 Ea.	92.00
25	Amusement Supp. Co.	2-A-67 @ $180. Ea.	360.00
	" "	2-P-63 @ $138.75 Ea.	277.50
20	Elec. Supp. Corp	PA-86	87.75
25	Dooleyphone Co.	PA-86	97.50
	"	PA-88	80.00
24	American Tel. & Tel.	PA-86	105.00
27	H. Steinman	PA-86	87.75
	"	101 Speaker Rect.	25.20
	Radio Air Service	A-88	72.00
30	Elec. Supp.	PA-86	87.75

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AMERICAN TRANSFORMER COMPANY

Transformer Specialists — *Electrical Manufacturers*

178 EMMET ST., NEWARK, N. J.

Telephone Terrace 3-4444

ROYALTIES APRIL 1931 CONTINUED

Apr. 10	Genl. Talking Pictures	PA-84		$ 72.00	
30	Officer in Charge	PA-83	2 @ $87. Ea.	174.00	
25	E. M. Zelony	A-80		202.50	
24	H. Steinman	P-73		42.75	
24	Radio Air Service	PA-64		550.00	
-	" "		2 - 2AP @ $46. Ea.	92.00	
30	Sta. W. L. W. L.	P-77		290.00	
-	H. Steinmann	PA 86		87.75	
-	"	P-101	2 @ $25.20 Ea.	50.40	
				$6953.85	

Less CREDITS:					
Apr. 7	Voltaphone Co.	P-32		$ 126.00	
	"	A-56		180.00	
	"	PA-39		189.00	
	Universal Sd. Sys.	PA-86		97.50	
14	E. Markell	A-72		105.00	
-	"		2 A-53 @ $105.Ea.	210.00	
15	Ad. Auriema	P-83		49.98	
-	"	PA-84		55.04	
-	"	PA-85		61.92	
-	"	PA-86		66.08	
-	Wilmington Elec.	P--51		300.00	
16	Universal Sd. Serv	PA-85		83.25	
28	Genl. Talk. Pict.	PA-39		134.90	1658.57
					$5295.28

7 1/2% Royalty on $5295.28 = $397.14 Royalty for Month

= F3

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AMERICAN TRANSFORMER COMPANY

Transformer Specialists — *Electrical Manufacturers*

178 EMMET ST., NEWARK, N. J.

Telephone TErrace 3-4040

(14)

ROYALTIES MAY 1931

Independent Radio -		$ 97.50
Radio Sta. WSAZ -	2 - P-77 $292.50 Ea.	585.00
Mr. Knowles -	PA-84S	80.00
Amusement Supp. -	A-67	180.00
" -	P-63	138.75
Radio Air Serv. -	A-67B	140.40
" " -	P-63B	108.22
Bell Tel. Lab. -	P-106	160.00
WMD Greathead -	PA-83	65.26
WTAR Radio Corp.-	P-77	200.00
C. C. Langevin -	P-108	85.00
W. G. Preddy -	PA-86	87.50
Elec. Supp. Co. -	2 PA-86 @ $87.75 Ea.	175.50
Royal Oaks Bdcstg	P-77	195.00
R.V. Terry -	PA-86	97.50
Radio Air Service	PA-86	87.75
Buffalo Even. News	P-77	292.50
Ad. Auriema -	PA-86	78 .00
Cross Mfg. -	PA-86	97.55
C. C. Langevin -	PA-86	87.75
E. M. Zelony -	PA-86	87.75
Amusement Supp. -	A-67	180.00
" " -	P-63	138.75
Elec. Supp. Co.--	2 PA-85 @ $81. Ea.	162.00
Electro Sound Prod	PA-84	80.00
Wireless Egert -	PA-84	72.00
Emmanuel Miss. Coll	PA-86	117.00
" "	A-88	96.00
Ray Smith Co. -	PA-86	97.50
Sound System Eng-	PA-83	72.50
" " -	PA-86	97.50
Universal Sd. & Serv	2 -PA86 @ $87.75	175.50
		$4553.62

ITS:

13 F. V. Gould-PA51		$ 275.00	
15 Bamberger Bdcstg.-	39 PA	195.00	
" "	- 86P	108.75	
" "	- 36A	180.00	
25 Good-all Elec. -	2 - A-55 @ $78. Ea.	156.00	
29 Elec. Supp. Co.	- PA-86	87.75	
Wired Radio	- P-77	200.00	
Warner Bros	- PA-86	97.50	1270.00
			$3283.62

7 1/2% of $3283.62 = $246.27

54

1611

12

AMERICAN TRANSFORMER COMPANY

Transformer Specialists — *Electrical Manufacturers*

178 EMMET ST., NEWARK, N. J.

Telephone TErrace 3-4444

ROYALTIES JUNE 1931

June	5	Electro-Phone Corp	PA-86	$ 87.75
	3	Sun Radio Co.	PA-85	65.25
		Elec. Supply Corp.	A-89	40.50
		" " "	A-89	40.50
		" " "	PA-85	81.00
		L. Deans	PA-86	87.75
	4	Electro Sound Products	PA-84	80.00
		Universal Sd. & Serv.	A-87	180.00
		" " "	P-63	138.75
	1	" " "	A-36	150.00
		" " "	P-32	108.75
		" " "	PA-39	195.00
	5	Universal Amplifying Co.	PA-86	87.75
	9	Sta. WJBK	P-77	292.50
		L. E. Wyant	PA-86	97.50
	10	K. J. Banfer	A-36	130.00
		"	P-32	94.25
		"	PA-39	169.00
		Ad Auriema	PA-86	78.0
	9	H. N. Steinman	PA-86	87.75
	10	Electro Sound Products	2-PA-84 @ $80. Ea.	160.00
		E. Markell	2-A89 @ $54. Ea.	108.00
	8	H. N. Steinman	P-101	42.00
	5	Hughes-Peters Elec.	P-101	25.20
	13	Simplimus	A-89	45.00
		"	PA-86	90.00
	11	Elec. Serv. Supp.	PA-84	80.00
	16	Simplimus, Inc.	PA-85	90.00
	17	George Rogers	PA-86	87.75
	15	Universal Sound & Service Co.	A-36	150.00
		" " "	PA-39	195.00
		" " "	P-32	108.75
	16	H. N. Steinman	PA-84	72.00
		"	P-101	25.20
	20	Simplimus	A-89	67.50
		"	PA-85	90.00
	16	C. C. Langevin	PA-85	81.00
	17	Elec. Serv. Supp.	A-88	80.00
	23	L. E. Wyant	A-88	80.00
		Ad Auriema	A-88	64.00
	20	E. Markell	A-89	45.00
		"	PA-86	97.50
	19	K. J. Banfer	3-P-101 @ $25.20 Ea.	75.60
	22	S. L. Baraf	2 PA-86 @ $87.75 Ea.	175.50
	24	Electro-Fone Corp	PA-84	72.00

85

AMERICAN TRANSFORMER COMPANY

Transformer Specialists — *Electrical Manufacturers*

178 EMMET ST., NEWARK, N. J.

Telephone Humboldt 2-4444

June Continued

June 23 - Benier Mfg. Co.----------	PA-86 ----------------	$ 87.75	
25 - Genl. Film Co.----------	PA-86 ----------------	97.50	
- Universal Amplifying ------	PA-86 ----------------	87.75	
27 - Thos. A. Edison ----------	PA-84 ----------------	80.00	
30 - Genl. Talking Pictures ----	PA-84/-10-@-$196. Ea.---	1960.00	
26 - Electro Sound Products ----	PA-84 ----------------	72.00	
23 - Elec. & Radio Distrib Co.---	A-36 ----------------	150.00	
- " "	-- P-32 ----------------	108.75	
- " "	-- PA-39 ----------------	195.00	
- " "	-- A-30 ----------------	225.00	
- " "	-- P-102 ----------------	117.00	
			$7751.75

CREDITS:

June 12 - Radio Air Service ---	PA-84 -----------	$550.00	
18 - E. Markein To correct	invoice -----------	18.00	
24 - H. N. Steinman--------	To correct invoice -----	16.80	584.80
			$7166.95

7 1/2% Royalty on $7166.95 = $537.52

1613

Transformer Specialists

TErrace 3-[illegible]

#19

AMERICAN TRANSFORMER COMPANY

178 Emmet St. Newark, N. J.

ROYALTIES FOR JULY 1931.

July 7	- Station KSOJ-Sioux C. Journal--P-77-Recv-	$ 200.00
	- Genl. Talking Pictures Corp.-11-PA-51-Amp.	2156.00
10	- Ad. Auriema - 1 PA-85 Amplifi r-----------	58.00
9	- Pacific Gas & Elec. Co. 1 PA-86 Ampli.---	87.75
11	- Universal Sound & Serv. Co. 1 A-67 Ampli.-	180.00
	" " " " 1 P-65 Pr.Sup-	138.75
9	- Eugene GWile 1 PA-85 Amp.----------------	81.00
14	- Brown & Maine 1 PA-86 Amp.---------------	97.50
15	- Electro Sound Prod. 2 PA-84 Amp.$72. Ea.--	144.00
14	- Genl. Talk. Pict. 42 A-41B Amp. @ $47. Ea.	1974.00
3	- Draclair Amusement Co. 1 PA-86 Amp.--------	97.50
13	- Universal Sound & Service Co. 1 PA-86 Amp.	87.75
16	- Radio & Elec. Distributors 1 PA-86 Amp.---	87.75
22	- Radio Elec. Sistributers 1 A-88 -----------	80.00
20	- Wenger-Brill Co. 1 PA-86 Amp.-------------	87.75
24	- Renier Mfg. Co. 1 PA-86 Amp.--------------	87.75
28	- K. J. Banfer- 1 PA-39 --------------------	195.00
	- " - 8 P 102 @ $117. Ea.----------	936.00
	- " - 6 P 63B @ $142.50 Ea.--------	855.00
	- " - 6 A 80B @ $292.50 Ea.--------	1755.00
	- " - 2 P 109 @ $195. Ea.----------	390.00
	- " - 4 P 77 @ $292.50 Ea.--------	1170.00
	- " - 7 A 83E @ $90. Ea. ----------	630.00
24	- D'Elia Elec. Co. 1 PA-85 Amp. ------------	81.00
	- " " 1 A-88 Amp.------------------	72.00
27	- M & H. Sporting Goods 1 PA-84 Amp.-------	77.00
31	- Genl. Talk. Pict. 24 PA-51B @ $196. Ea.---	4704.00
	- " " 42 A-41B @ $47. Ea.------	1974.00
28	- W. G. Preddy 1 PA-86 Amp. -----------------	87.75
31	- C. Alvord 1 PA-85 Amp.--------------------	87.00
31	- K. J. Banfer 3 P-109 Panels @ $169. Ea.---	507.00
		$19166.25

LESS CREDITS:

July 22	- Western Rad. Eng. P-77 billed 4/10 @ $292.50 should be $200.	-$-92.50
29	- Radio & Elec. Dis. 1-A-88 Amp.	80.00
31	K.J.Banfer 6 A-80B Amp. billed @ $1755. should be $1521.----	234.00
	- 6 P-63B billed $855. should be $741.---------	114.00
	- 8 P-102 Panels billed @ 936. should be 811.20-	124.80
	- 7 A-83 Amp. billed $630. should be $546.------	84.00
	- 1 PA-39 billed @ $195. should be $169.-----------	26.00
	- 4 P-77 billed @ $1170 should be $1014.----------	156.00

80

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TErrace 3-4444

Amplifier
Equipment

AMERICAN TRANSFORMER COMPANY

178 Emmet St. Newark, N. J.

ROYALTIES FOR JULY CONT'D

July 31	K.J. Banfer 2-109 Panels billed $390. should be 338.----------	52.00	
	- 1-P-109A. Supp. billed $195. should be 169. ----------	26.00	
31	- Elec-tro-fone Corp. 1-PA86 Amp.---------	87.75	1077.05
			$18089.20

7 1/2% of $18089.20 = $1356.69

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PAGE

DEFENDANT'S EXHIBIT M

AMERICAN TRANSFORMER COMPANY

MAKERS OF ELECTRICAL APPLIANCES

172-188 EMMET ST., NEWARK, N. J.

TELEPHONE TERRACE 4444

May 29th, 1929

A. Schlesinger & Sons,
218 West 42nd Street,
New York City.

Attention Mr. M.A. Schlesinger

Dear Sirs:-

Mr. Zelony informs me that you would like the patent numbers applying on the large amplifiers we have recently sold you; also you would like to know whether we are paying royalties on these amplifiers.

We pay a 7½% royalty to the Radio Corporation of America on all the amplifiers we manufacture whether they are for you or any one else. Our license agreement with the Radio Corporation is naturally very explicit in this matter. The royalties are paid in a lump sum at certain intervals throughout the year.

The license numbers which apply to our standard Type 25A amplifier, such as we have manufactured for you, are as follows:-

Type A Panel	Type P Panel	Type PA Panel
1128292	1195632	1128292
1129942	1201272	1195632
1195632	1231764	1201272
1231764	1251377	1231764
1273627	1273627	1251377
1313094	1622170	1273627
1349252		1426754
1403932		1465332
1459412		
1465332		
1520994		
1530961		

These numbers appear on license notices attached to the rear of panels.

The patent numbers which appear on the license notice attached to the Type A-41 low level amplifier are as follows:- 1231764, 1273627, 1297188, 1375739, 1401121, 1426754, 1465332, 1520994 and 1403475.

Yours very truly,
AMERICAN TRANSFORMER COMPANY,
J. L. Schermerhorn
J.L. Schermerhorn
General Manager

JLS/MGS

1616

DEFENDANT'S EXHIBIT N

Defendant's Exhibit N

a plate circuit voltage should be used such that when the grid is set at the same potential as its average potential under operating conditions the plate current is the same as its average operating value. The plate-circuit voltage is frequently called the " *B* " battery voltage.

It has become customary in speaking of grid potential to refer the grid to the *negative end of the filament;* unless otherwise stated all the curves shown in this text are so given. In case the characteristics are desired when the grid is connected to the positive end of the filament it is only

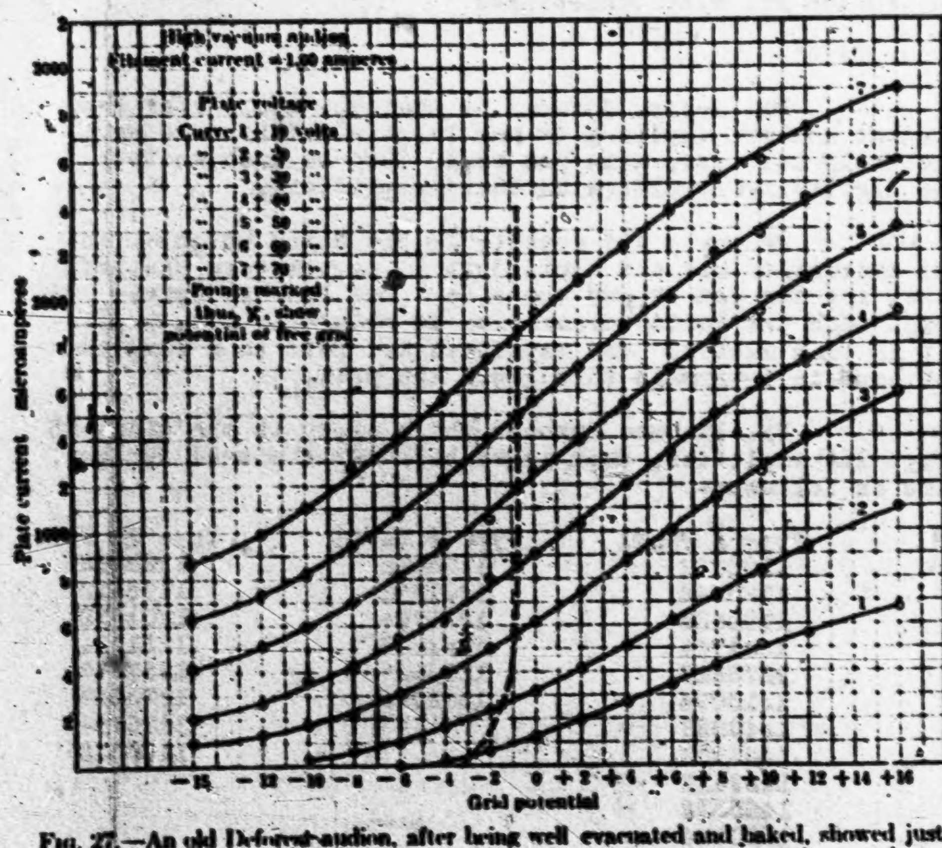

Fig. 27.—An old Deforest audion, after being well evacuated and baked, showed just as regular characteristics as the modern tube.

necessary to move the " zero grid potential " along, on the curve sheets as given, by an amount equal to the *IR* drop in the filament.

In Fig. 27 is shown a set of plate-current curves from an old Deforest audion, after it had been re-evacuated to take off all possible gas. The plate circuit had no added resistance except that of the *B* battery, which was so low that the variation in plate current did not appreciably affect the plate potential. On the curve sheet is shown the locus of the " free grid potential," i.e., the potential at which the grid set itself when its

References Cited by the Patent Office During Prosecution of Lowenstein Patent in Suit No. 1,231,764. 4849

De Forest	841,387
" "	995,126
Weintraub	921,930
Von Lieben	1,038,910
Stone	884,110

References Cited by the Patent Office During Prosecution of Mathes Patent in Suit No. 1,426,754. 4850

Colpitts	1,137,384
Von Lieben Reissue	13,779
Heising	1,199,180
German Patent	268,460
Pierce	1,127,371
Langmuir	1,223,496
"	1,273,627
Arnold	1,129,942

4851

4852 Opinion, Byers, D. J.

UNITED STATES DISTRICT COURT,

SOUTHERN DISTRICT OF NEW YORK.

WESTERN ELECTRIC COMPANY, INCORPORATED, ELECTRICAL RESEARCH PRODUCTS, INC., and AMERICAN TELEPHONE AND TELEGRAPH COMPANY, Plaintiffs, against GENERAL TALKING PICTURES CORPORATION, Defendant.	In Equity Nos. 50-175, 50-177, 50-178.

4853

September 16, 1936.

4854 CHARLES NEAVE and HENRY R. ASHTON, ESQS., Solicitors for Plaintiffs (F. T. Woodward, H. A. Pattison and E. J. Driscoll, Esqs., of Counsel).

DARBY AND DARBY, ESQS., and ZEIGER AND BERLINER, ESQS., Solicitors for Defendant (Samuel E. Darby, Jr., Ephraim Berliner and Joseph J. Zeiger, Esq., of Counsel).

BYERS, D. J.

These patent causes were tried together during February, 1934. Intervening engagements of court and counsel delayed argument until November 27, 1935.

The pleadings disclose that the plaintiff American Telephone and Telegraph Company is the owner of the several patents involved, and that the plaintiffs Western Electric Company, Inc., and Electrical Research Products, Inc., are the holders of licenses from the first-named; that the Western Electric Company, Inc., possesses all rights under or arising from said patents to exclude others from the manufacture, use, etc., of the patented devices; that the Western Electric Company, Inc., and Electrical Research 4856
Products, Inc., are possessed of all claims arising out of alleged infringement as set forth in the bill, and the rights for their own benefit to bring suit against any infringer.

The patents are eight in number, and it is unnecessary to allocate them to the three causes enumerated, because the issues are commonly identical.

The defendant was organized in September, 1928, under the laws of Delaware, and its business is that of leasing, recording and reproducing equipment for talking motion pictures in the 4857
United States; it is said to have taken over the De Forest Phonofilm Corporation which then had installed, in various theaters in the United States, talking motion picture equipment according to the sound on film system.

The plaintiffs allege that the defendant, without a license under any of the said patents, has illegally made, sold and used within the United States the inventions and improvements contained in the said patents; to restrain this alleged infringement the plaintiffs seek an injunction and the delivery to them of the alleged infringing devices and an accounting with costs.

In addition to denials, the defendant pleads that it does not manufacture, use or sell the apparatus charged to infringe, and that said apparatus was manufactured and sold to it as manufactured under the patents in suit, by a licensed manufacturer under the patents, or by those having rights to grant such licenses; and that this was done by a licensee of the owner of the patents with the latter's knowledge, consent and/or acquiescence. Also the validity of the
4859 patents is put in issue.

The major controversy concerns the legal effect of the sale to the defendant of the amplifying devices manufactured under the patents by American Transformer Company, holding a license so to manufacture and sell to certain classes of purchasers only as set forth in the license; each of the amplifying devices so purchased by defendant bears a notice reading: "This apparatus is licensed only for radio, amateur, experimental and broadcast reception under the following patents of the Radio Corpora-
4860 tion of America and Associated Companies." (The Radio Corporation of America was the licensing medium of several corporations including the three plaintiffs in this cause, and the inclusion of its name in this recital does not alter the status of the parties as heretofore stated.)

The amplifying devices required tubes which the defendant procured in the open market by purchase from authorized distributors; each tube carton bore a license notice reading as follows:

"License Notice.

"In connection with devices it sells, Radio Corporation of America has rights under

patents having claims (a) on the devices themselves and (b) on combination of the devices with other devices or elements, as for example in various circuits and hookups.

"The sale of this device carries a license under the patent claims of (a), but only for (1) talking machine uses, (2) radio amateur uses, (3) radio experimental uses and (4) radio broadcast reception; and only where no business features are involved. 4862

"The sale does not carry a license under patent claims of (b), except only (1) for legitimate renewals and repairs in apparatus and systems already licensed for use under such patent claims on combinations, (2) for assembling by amateurs and experimenters, and not by others, with other licensed parts or devices, or with parts or devices made by themselves, but only for their own amateur and experimental radio uses where no business features are involved and not for sale to or for use by others, 4863
and (3) for use with licensed talking machines and licensed radio broadcast receiving devices; and only where no business features are involved.

"This device is licensed for no other use unless, by special written contract of sale with Radio Corporation of America, the purchaser has agreed to use it in some other special manner only, as set forth in the contract of sale. The right to employ the device in such special manner is non-transferable except by special agreement with Radio Corporation of America."

The amplifying apparatus covered by the patents was produced and sold by over thirty concerns holding licenses from the plaintiffs; all of the devices, however, contained the restrictive notice first above quoted.

The defendant's position is shortly this:

That, since the plaintiffs licensed the American Transformer Company to make and sell the amplifying devices, when sales had been made by it, those devices became the absolute property
4865 of the purchaser, free from any restriction whatever, and that the purchaser had the right to use them in any way that it saw fit; in other words, to disregard the terms of the notice, although actual knowledge is conceded on the part of the purchaser, of the restricted nature of the license and of the terms of the notice at the time of purchase.

The special argument is made to avoid infringement, that the amplifying device could not be used without tubes and, as the tubes were purchased in the open market and could serve no
4866 purpose other than as equipment for amplifiers, the purchaser was free from any restriction concerning the use thereof, and particularly it was at liberty to insert the tube or tubes in these amplifiers so acquired, and make use of the complete devices without regard to the terms of either or both notices.

It is next contended that, even though the foregoing defenses should not be sustained, the court should find from the evidence that the plaintiffs acquiesced in the acquisition by the defendant of the amplifiers, with knowledge that the defendant intended to lease them for the use of moving picture theaters, and hence the plain-

tiffs should not now be heard to complain of the alleged infringement. This branch of the case involves a closely contested question of fact based upon numerous conversations between officers and representatives of the plaintiffs, and the defendant's president in connection with the development of the defendant's business.

Infringement in the usual sense is denied; it is admitted that the devices leased by the defendant to its customers embodied the inventions in the several patents, but it is asserted that 4868
each patent is for a combination of elements, namely, the structure containing the circuits and instrumentalities included therein which form a complete whole, and the radio tube or tubes which are also complete as such. It is urged that the latter require replacement from time to time as they wear out and that they have no function apart from their place in the amplifier. Therefore, as stated the defendant urges that infringement did not arise from the separate purchases of the structures, and the tubes, and the only use of the latter for which they were designed 4869
and manufactured.

Otherwise the question of infringement is not presented; thus, if the patents are valid, and the license system is lawful, and the plaintiffs have not consented to or acquiesced in the complained of acts on the part of the defendant, the plaintiffs are entitled to a decree.

Finally it is urged that the patents in suit are invalid for several reasons:

(a) That section 4886 of the Revised Statutes constitutes a statutory bar as to five of the patents, because commercial use of the device was

shown to have been practiced more than two years before the applications were filed.

(b) That Lowenstein, No. 1,231,764, is invalid for lack of invention.

Mathes, No. 1,426,754, is invalid for anticipation.

Arnold, No. 1,329,283 (power circuit) is invalid because of anticipation and want of patentable invention.

4871 Arnold, No. 1,349,252 (straight line characteristic) is invalid because of anticipation, want of patentable invention, and double patenting.

Arnold, No. 1,403,475 (resistance capacity coupling) is invalid for abandonment and complete anticipation.

Arnold, No. 1,448,550 (definite input impedance) is invalid for anticipation and double patenting.

Arnold, No. 1,465,332 (common plate supply) is invalid for anticipation.

Arnold, No. 1,520,994 (gain control) is invalid
4872 for want of novelty or patentable subject-matter.

These issues invite consideration in the order of their importance; the question concerning the legal power of the plaintiffs to restrict the defendant's use of the amplifiers is the more appropriate for consideration first, since the Lowenstein patent has been adjudicated and upheld by the Circuit Court of Appeals for the Second Circuit in the case of *Western Electric Company v. Wallerstein,* 60 Fed. (2d) 723. Validity thus having been established, there is a sufficient patent structure of plaintiffs to require determination primarily of this aspect of the controversy.

In considering the right of the defendant as

asserted to disregard the limitation upon use which is contained in the notices, it is necessary to recall that the defendant derived its title to the amplifier units (apart from the tubes) from the American Transformer Company, a licensee under the patent.

It should be said that no innovation was involved in the license methods employed by the plaintiffs and which are challenged by the defendant. For convenience, there is quoted from the record the following stipulation: 4874

> "It is stipulated that it is common practice, where a patented invention is applicable to different uses, to grant written licenses to manufacturers under United States Letters Patents restricted to one or more of the several fields of use permitting the exclusive or non-exclusive use of the invention by the licensee in one field and excluding its use in another field."

The different uses which these patented inventions may serve are commercial as, for instance, wire or wireless telephony for tolls, talking motion pictures in theaters for profit, etc.; and private, namely, amateur and experimental purposes, including broadcast reception. It is clear that the development of the plaintiffs' business could lawfully proceed along lines determined by them, which might well involve the application of different license methods to different fields. 4875

Further, the practice here employed calls attention to the limited terms of the license under which the American Transformer Company manufactured and sold the power supply and

4876 power amplifying units (under license dated February 1, 1927, expiring July 1, 1931) "for radio amateur reception, radio experimental reception, and radio broadcast reception."

The license agreement defines these fields in the following provisions:

> "2. (a) That the term 'amateur reception,' for the purpose of this Agreement, means reception by one not a professional
> 4877 investigator who is more than a mere broadcast listener, and who evidences his interest in the art of wireless telephony by study, investigation, or experiment in the art.
>
> "(b) That the term 'experimental reception,' for the purposes of this Agreement, means the use in a laboratory, college, school or scientific society, or in professional investigations, but not in any case reception of messages, directly or indirectly for business purposes.
>
> 4878
>
> "(c) That the term 'broadcast reception,' for the purpose of this Agreement, is defined as follows: The reception from radio telephone broadcast stations of news, music, speeches, sermons, advertising, and entertainments, educational and similar matter, or any of them, or combinations of any of them, for the purpose of exhibition, entertainment or instruction."

Further it is provided in paragraph 5:

> "5. The Licensee shall affix to all Licensed Apparatus manufactured and sold by the Li-

censee under the terms of this Agreement, a license plate reading: 'Licensed only for Radio Amateur, Experimental and Broadcast Reception' and the word 'Patented,' and giving the dates of the patents and which are, in the opinion of the Radio Corporation, used in such Licensed Apparatus. The Licensee further agrees that any and all catalogs, circulars or price lists, or general advertising, of the Licensee, shall contain a statement to the effect that the Licensed Ap- 4880
paratus so manufactured and sold by the Licensee, is 'Licensed only for Radio Amateur, Experimental and Broadcast Reception,' and that all such catalogs, circulars, or price lists, or general advertising shall be subject to the approval of the Radio Corporation with respect to any reference to the Licensors or any of them, or to any matters relating to this Agreement."

Knowledge on the part of the defendant of the limitations embodied in the license agreement 4881
of the American Transformer Company was conceded by defendant's counsel, who stated:

"The American Transformer Company was licensed under each of the patents in suit, * * * by a document which granted a license to the American Transformer Company, which license was joined in by the American Telephone and Telegraph Company, and * * * the apparatus before the court under charge of infringement was manufactured by the American Transformer Company under that license. That license

4882 was limited by express language in the license agreement to a certain use. The apparatus was sold to us with that limited license of use, in accordance with the express terms of the contract notice right on the instrument itself. That takes care of the apparatus itself, so that it raises a square issue here, about which there is no contention as I understand it."

4883 That counsel did not overstate the extent of the knowledge possessed by his client appears from a letter in evidence written by the American Transformer Company to the defendant November 23, 1928, the first and second paragraphs of which are as follows:

> "We have your letter of the 17th in regard to amplifiers to be used with phonographs and the like in theatres.
>
> "The license which we have with the Radio Corporation of America is that the
> 4884 amplifier is to be used for broadcasting reception and for experimental and amateur use only and not for commercial use. That is the type of license notice which is placed upon the amplifier and is the only way which we can sell them."

The defendant having been thus apprized of the precise legal situation, it becomes necessary to determine whether the licensee could confer greater rights upon the defendant company than were possessed by itself. If it could, the basis for its capacity so to endow the purchaser must reside either within the license or exterior to it. No other possibility exists.

If it is within the license, then the terms of the latter are without legal significance and the attempted restrictions must fail for lack of legal sanction; if the power proceeds from some source exterior to the license, identification thereof ought to be possible, although none has been attempted.

This aspect of the controversy confronts the defendant and may not be ignored by the contention that legal title to the amplifiers necessarily carried the right to unrestricted use. 4886

If there is no distinction between "* * * the property right in the materials composing a patented machine, and the right to use for the purpose and in the manner pointed out by the patent * * *" (*Henry* v. *A. B. Dick Co.*, 224 U. S. 1), then the defendant is justified in disregarding the issue; but if such a distinction exists its effect does not disappear from the case because the defendant chooses not to discuss it.

The opinion is presently held that the Supreme Court has not thus far decided that legal 4887
ownership of a patented device is necessarily incompatible with a restricted right to use it; if that understanding is correct, the licensee who conveyed legal title to these amplifiers, to this defendant, did not thereby confer upon the latter the legal right to offend against the restriction upon use, since it lacked the legal capacity to bring about that result.

The defendant argues that, so long as a sale of the devices was involved, it mattered not whether the sale was made by one who lacked the power to admit the defendant to a field from which the patentee had taken pains to exclude

4888 it; that, since the defendant's legal title to the chattels was unassailable, any effort by the plaintiffs to control the use of the patented device disappeared or evaporated when the defendant acquired ownership of the amplifiers. It is said that such is the necessary consequence of the cases upon which defendant relies, although apparently none decided that such a result came about through a sale made by a licensee whose franchise in terms disabled it from

4889 accomplishing that purpose.

The court will lay aside for the moment the question of whether the licensee sought to exercise powers which were denied to it according to the terms of the license; and whether, if it did, the plaintiffs' rights were thereby affected.

For the present, it may be said that *Mitchell* v. *Hawley*, 16 Wall. 544, is thought necessarily to involve the proposition that a patent licensee can impart through a sale to a purchaser of the patented device nothing which is forbidden by the terms of his license. See also *Interna-*

4890 *tional Pavement Co.* v. *Richardson*, 75 Fed. 590.

The decisions upon which the defendant stands are said to declare that the sale by the patentee or his licensee of the patented article "ends the patent monopoly and with it all right to restrict its (the patented article's) use."

Mitchell v. *Hawley, supra,* is one authority to the contrary.

Adams v. *Burks*, 84 U. S. 453, and *Hobbie* v. *Jennison*, 149 U. S. 355, involve the right of assignees of the respective patents to manufacture and sell within their specified territories, although the patented articles were used elsewhere. It did not appear that restrictions as to

the place of use were imported into the relations of the parties. In the concluding portion of the opinion in the latter case, it is said:

> "It is easy for a patentee to protect himself and his assignees, when he conveys exclusive rights under the patent for particular territory. He can take care to bind every licensee or assignee, if he gives him the right to sell articles made under the patent, by imposing conditions which will 4892
> prevent any other licensee or assignee from being interfered with. There is no condition or restriction in the present case in the title of the defendant. He was the assignee and owner of the patent for the state of Michigan."

This quotation is at variance with the defendant's thesis.

Keeler v. *Standing Folding Bed Co.,* 157 U. S. 659, is a similar case.

The defendant also relies upon the price-fixing 4893
cases reviewed in *U. S.* v. *General Electric Co.,* 272 U. S. 476. Those cases are described by the court itself in the following language:

> "These cases really are only instances of the application of the principle of *Adams* v. *Burke,* 17 Wall. 453, 456, already referred to, that a patentee may not attach to the article made by him, or with his consent, a condition running with the article in the hands of purchasers, limiting the price at which one who becomes its owner for full consideration shall part with it. They do

no consider or condemn a restriction put by a patentee upon his licensee as to the prices at which the latter shall sell articles which he makes and only can make legally under the license. The authority of *Bement* v. *Harrow Company* (186 U. S. 70), has not been shaken by the cases we have reviewed.

"For the reasons given, we sustain the validity of the license granted by the Electric Company to the Westinghouse Com-
4895 pany. The decree of the District Court dismissing the bill is affirmed."

The presently important aspect of that case deals with the license from the General Electric Company to the Westinghouse Company to make and to sell at a certain price, electric bulbs covered by the General Electric patents. The theory on which that license was held to be valid is thus expounded by the court, at page 490:

4896 "The patentee may make and grant a license to another to make and use the patented articles, but withhold his right to sell them. The licensee in such a case acquires an interest in the articles made. He owns the material of them and may use them. But if he sells them, he infringes the right of the patentee, and may be held for damages and enjoined. If the patentee goes further, and licenses the selling of the articles, may he limit the selling by limiting the method of sale and the price? We think he may do so, provided the conditions of sale are normally and reasonably adapted to

 4897

secure pecuniary reward for the patentee's monopoly. One of the valuable elements of the exclusive right of a patentee is to acquire profit by the price at which the article is sold. The higher the price, the greater the profit, unless it is prohibitory. When the patentee licenses another to make and vend, and retains the right to continue to make and vend on his own account, the price at which his licensee will sell will
necessarily affect the price at which he can 4898
sell his own patented goods. It would seem entirely reasonable that he should say to the licensee, 'Yes, you may make and sell articles under my patent, but not so as to destroy the profit that I wish to obtain by making them and selling them myself.' He does not thereby sell outright to the licensee the articles the latter may make and sell, or vest absolute ownership in them. He restricts the property and interest the licensee has in the goods he makes and proposes to
sell." 4899

If the patentee might limit the method of sale employed by the licensee, clearly there was retained in the former a right of control having its origin in the grant of the patent, which existed apart from and was not to be confused with the transition of legal title to the bulbs from the licensee to a purchaser from the latter.

If this were not so, there would be no substance to the statement that the patentee may protect the distribution that he retains against the inroads of the licensee's competition. Here it would seem that a parity of reasoning would

justify the plaintiffs in protecting their own rights to sell these amplifiers in the special fields of distribution not open to the licensee, against the competition alike of the licensee and of those claiming—through sale by it—the right to invade those fields. If this is sound, the acquisition of instruments of invasion, with knowledge of the limitation of use attaching thereto, puts the purchaser into the same category as the licensee itself, so far as this ques-
4901 tion is involved.

Apparently the defendant would construe the *General Electric* case to protect the patentee only against the competition of its licensee and not against that of purchasers from the latter. Perhaps that position is sound, but, if it is, demonstration is not to be found in the other cases upon which reliance is had, nor was the element of actual knowledge of the licensee's limited functions present in any of them.

The most important is that of *Motion Picture Patents Company* v. *Universal Film Manufac-*
4902 *turing Company,* 243 U. S. 502. In that case, the manufacturer had licensed another to make and sell the patented device and required that the latter should contain a notice to the effect that the machine could only be used in connection with unpatented articles, and the decision was that this could not be permitted. The questions for decision are those stated by the court:

> "First. May a patentee or his assignee license another to manufacture and sell a patented machine, and by a mere notice attached to it limit its use by the purchaser or by the purchaser's lessee, to films which

are no part of the patented machine, and which are not patented?

"Second. May the assignee of a patent, which has licensed another to make and sell the machine covered by it, by a mere notice attached to such machine, limit the use of it by the purchaser or by the purchaser's lessee to terms not stated in the notice, but which are to be fixed, after sale, by such assignee, in its discretion?"

The court in its decision answers these questions in the negative and overrules the decision of *Henry* v. *A. B. Dick Company*, 224 U. S. 1. 4904
The court says quite definitely that the grant of the patent did not confer upon the owner the right by notice attached to the machine to "in effect extend the scope of its patent monopoly by restricting the use of it to materials necessary in its operation, but which are no part of the patented invention, or to send its machines forth into the channels of trade in the country subject to conditions as to use or royalty to be paid, to be imposed thereafter 4905
at the discretion of such patent owner."

As the decision is here understood, the court did not decide the issue upon the ground that title had passed to the machines and therefore their use was not subject to any restriction imposed by the patentee, but for the reason quoted; namely, that the patent could not be used as an instrument of oppression to project its monopoly so as to cover unpatented things.

Carbice Corporation of America v. *American Patents Development Corporation*, 283 U. S. 27, is to the same effect, and does not touch the issue here discussed.

It should be said that the right which the plaintiffs assert, to restrict the use of the patented devices, has received tacit or direct recognition in the following cases:

> *Skee Ball Co.* v. *Cohen,* 286 Fed. 275;
> *Dickerson* v. *Tinling,* 84 Fed. 192;
> *Dickerson* v. *Matheson,* 57 Fed. 524;
> *General Electric Co.* v. *Continental Lamp Works, Inc.,* 280 Fed. 846.

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In the last, a preliminary injunction was ordered on appeal in this circuit where it was urged that the purchaser of bases for use with electric light bulbs acquired a tacit permission to use the bulbs themselves which were covered by Letters Patent, although the bases contained a notice reading:

> "The sale of bases by us confers on the purchaser no license under any patents of the General Electric Company covering or
> 4908 relating to the structure of Incandescent Lamps, or the materials, machines, or processes used in their manufacture."

In the course of its opinion, the court says:

> "Use of an invention can only be obtained on the inventor's terms. Without paying or doing whatever he exacts, no one can be exempt from his right to exclude, and, whatever the terms, the courts will enforce them, provided only that the licensee is not thereby required to violate some law outside of the patent law. (Citing cases.)

"So, where the owner of a patent sells a patented article subject to a restriction, the purchasers, with notice of this limitation, could acquire no better right than strangers to infringe upon that part or claim of the monopoly still secured to the patentee. *Dickerson* v. *Tinling*, 84 Fed. 192."

See also: *Independent Wireless Telegraph Company* v. *Radio Corporation of America*, 269 U. S. 459. The matter decided in this case was that the patentee was properly joined as co- 4910
plaintiff by a licensee in an infringement suit, in which the defendant was charged with having used the patented device in violation of the rights which it acquired by purchase and which were defined in a label upon the device. The court said:

"The defendant, the Independent Wireless Company, has bought the same apparatus with the lawful right to use it in the amateur and experimental field only. The apparatus thus bought bears a label with 4911
such a limitation on its use. The charge in the bill is that the Independent Company is using the apparatus, or the part of it called 'radio tubes,' in the commercial radio field between ship and shore for pay and thus is violating the Radio Corporation's rights in this field."

In that case, the Radio Corporation was the licensee. The capacity of the Radio Corporation is described as follows:

"Thus there came from the De Forest Company to the Radio Corporation, ex-

> clusive rights to use and sell in the United States, for radio purposes, apparatus for transmission of messages, and especially for use between ship and shore for pay."

Clearly the opportunity was presented to the court to dismiss the litigation on the ground that the restricted use recited in the label was incompatible with the act of purchase and sale of the tubes, but the court did not so dispose
4913 of the case.

It results from the foregoing cases that the mere fact of sale by the licensee, American Transformer Company, to the defendant did not deprive the plaintiffs of their rights to exclude the defendant from the fields of operation and distribution of the patented device which the plaintiffs have reserved, according to the terms of the license granted to the American Transformer Company, to the defendant's actual knowledge.

Turning now to the question of acquiesence as
4914 alleged, on the part of the plaintiffs, in the purchases by the defendant from the American Transformer Company, it should be observed that this is a decidedly critical issue. If in fact the record demonstrates that the plaintiffs connived at or acquiesced in the defendant's purchases with knowledge of their purpose, and then later, through this litigation, sought to repudiate their former conduct, the plainest principles of equity would stand in their way.

The defendant made its first purchases of these amplifiers in the month of February, 1929, nearly five months after its incorporation. Thereafter the defendant leased a complete talking

motion picture equipment, which included one of these amplifiers, to a theater in Allentown, Pennsylvania, where the equipment was installed during the month of April. On the 19th day of that month, the plaintiffs' investigators examined the equipment in order to ascertain the precise facts with reference to the operation of the various circuits and whether the plaintiffs' patents were involved. This was a substantial task and a report, based upon the studies, was not completed until some time during the month of July, 1929, 4916
and by the end of August the executive officers authorized the institution of this suit; these several bills were filed September 13th.

The record indicates that there were other suits involving some or all of the patents now before the court, started during the months of April and June of 1929, but, in the absence of an understanding of the issues so presented, it is thought that such fact is of no present consequence. There is no plea of laches made for the defendant and consequently there is no necessity for making a finding on the subject. If there 4917
were, it would be in the negative.

The contentions of acquiescence involve four separate elements:

(a) Conversation said to have occurred between the president of the defendant and one or more of the executive officers of the Radio Corporation (the status of which has been heretofore explained) and the Western Electric Company and the Electrical Research Products, Inc.

(b) Conversations between the president of the defendant and the president of the American

4918 Transformer Company resulting in the writing of a letter, which is in evidence, by the latter to the defendant on July 24, 1929.

(c) Conversations between the president of the American Transformer Company and one of the engineers in the employ of the Western Electric Company, and one or more conversations between a special salesman of the American Transformer Company and the then president of the

4919 Electrical Research Products, Inc.

(d) The acceptance of payments from the licensee, with knowledge that they included royalties in connection with the sales made to this defendant.

The defendant urges that, by reason of the incidents connected with some or all of the foregoing, it must be found that acquiescence has been established by the proofs.

The extent to which the defendant may be thought to rely upon these things must be

4920 weighed in connection with its having procured, prior to any of the events in question, the advice of patent counsel to the effect that the license system employed by the plaintiffs was ineffectual and legally deficient. The defendant was, of course, justified in seeking to gain advantage from the practical as well as the theoretical or legal aspect of the situation, and it cannot be said, because it did not elect to stand upon either the alleged legal infirmities of the plaintiffs' methods and practice, or the conduct relied upon to establish acquiescence, that it may not now urge both theories of defense; but the attitude of mind on the part of the defendant's

president, as reflected in the evidence, may well be consulted in determining what the testimony may be deemed to have established concerning these issues of fact.

In order to discuss (a) above, it is necessary to have in mind the date of the letter referred to in (b) because it indicates that, as of July 24, 1929, the president of the defendant still deemed it necessary to secure written assurance that the supply of amplifiers would continue to be available to his company, and that royalties payable 4922
under the license were not in default, and that the licensee had conducted interviews with an unnamed representative of the Western Electric Company (quoting) "in which it was mentioned that we have been supplying these amplifiers freely to you and others and no question has been raised as to our rights to make such sales. As a matter of fact our books are open to inspection by the Radio Corporation of America and they are fully aware of the fact that we are dealing with you and they have raised no objection whatsoever." This is Defendant's Exhibit 4923
K.

The letter embodies an option for 2,000 amplifiers to be taken within a period of one year, and is signed by the president of the licensee. (He had been such from about the middle of June, 1929.) It may be said in passing that the genesis of that letter was never satisfactorily explained. The impression in the mind of the court is that it was inspired and composed outside of the licensee's office, but no finding on that subject can be made.

The question is: Why the letter, if, five months or so prior to its date, assurances had been given

for the plaintiffs, that the purchases by the defendant were acceptable to the plaintiffs?

The testimony relied upon to establish a prior tacit agreement with the defendant's president on the part of Mr. Otterson, president of the Electrical Research Products, Inc., Mr. Knox, vice-president of the same company, and Mr. Sarnoff, president of the Radio Corporation of America, is affirmative for the defendant on the part of Mr. Schlesinger, and is negative on the
4925 part of these other witnesses. The conflict is direct and one or the other version must be relied upon by this court.

It is probable that during parts of 1928 and the early months of 1929 the defendant's president had in mind a rather diplomatic and veiled effort to accomplish the purpose of gaining approval of these purchases, either before or after they were made; he was in fairly frequent consultation with the other gentlemen who have been named, in reference to patents—mostly De Forest patents—which his company was in the
4926 process of acquiring; of course, those representing the plaintiff companies knew what business Mr. Schlesinger was conducting and what its future requirements were likely to be.

They conferred, for instance, about his interests in moving picture theaters in South Africa, and doubtless they contemplated the possible establishment of business relations in that field which would be mutually profitable.

It is possible also that Schlesinger recalls remarks that he made concerning the business activities of his company which he intended to be sufficient to put the officers named of the plaintiff companies on notice that he was purchasing

amplifiers from the licensee in question. As stated, he had taken advice on the license question as early as September of 1928, and procured the said opinion of counsel, the date of which is not disclosed because its offer in evidence resulted in its exclusion under objections.

Thus Schlesinger's mental attitude during these months was either that the license system of the plaintiffs was legally objectionable, or that he could circumvent it through adroit discourse, but the utmost that can be attributed to the of- 4928
ficers of the plaintiffs, from the evidence, was a general understanding of the defendant's business, methods, and purposes. Having seen and observed the witnesses and having weighed their testimony carefully, the court is unable to conclude that there was anything approaching a meeting of the minds between the defendant's president on the one hand and the three other gentlemen named on the other, on the proposition that the purchase of these amplifiers by the defendant company from the American Transformer Company was consented to, approved of, 4929
or deemed to be unimportant, from the plaintiffs' standpoint.

This conclusion is fortified by the reflection that, if the defendant's president had been sure of his ground as the result of these various interviews with the officers of the plaintiffs, he would not have felt it necessary to exact the letter from the Transformer Company on the 24th of July, 1929, which has heretofore been referred to.

It is unnecessary to dwell at length upon the legal effect to be accorded to the interviews between Loughead, the president of the licensee,

and the president of the defendant. Nobody seriously urges that the licensee could expand its own powers and, by any representations, change or enlarge its legal capacity as a licensee of the plaintiff companies. It must be recalled that the defendant knew as early as November of 1928 of the terms of the restrictions under which the licensee sold these amplifiers, and no reputed consent on the part of Young, an engineer in the employ of the Western Electric Company, as-
4931 serted to have been evolved as the result of conversations between Loughead and him, could change the legal relations between the patentee and the licensee.

In this connection it is urged that Zelony, a special selling representative of the licensee, had fortified himself while making these sales to the defendant by interviewing Mr. Otterson at that time, and by mentioning the defendant company to him and the fact that sales were being made to it, which elicited no observation from Mr. Otterson save the statement that, so far as he was
4932 concerned, there was no objection.

Zelony so testified, and Otterson denied that the interview ever took place. The court relies upon the testimony of the latter as being inherently the more probable.

On this general subject, the plaintiffs point out that both Otterson, and, of course, the vice-president under him, and Sarnoff lacked power to give any legal consent to the change in the form of the license agreement held by the American Transformer Company or to confer upon the defendant the right to acquire the amplifiers in violation of the terms of the notice which each instrument bore.

This is sound as a legal proposition, but, in
view of the complex intercorporate relations
maintained by the plaintiffs and their associates,
concerning which familiarity could not be as-
cribed to outsiders, the decision on this branch
of the case will not be based upon that ground.
It is simply found, as a matter of fact, that the
defendant has not sustained its burden of proof
to establish acquiescence on the part of the plain-
tiffs in its purchase of the amplifiers from the
American Transformer Company for use in vio- 4934
lation of the terms of the notice attached to each
amplifier, and that on the contrary, when it made
these purchases, it knew that the American
Transformer Company did not have the legel ca-
pacity to make sales in violation of its own li-
cense agreement or in derogation of said notice.

Reference should be made briefly to the sub-
ject of royalties paid by the licensee to the Radio
Corporation, covering the sales of these ampli-
fiers to the defendant.

The evidence shows that during the month of
December, 1929, three months after these suits 4935
were filed, the American Transformer Company,
pursuant to request, began to furnish to the Ra-
dio Corporation lists of its customers (includ-
ing this defendant) to whom amplifiers had been
sold, and that, one year later, the royalty pay-
ments which applied to the defendant's pur-
chases were returned to and accepted by the li-
censee.

The defendant urges that some legal conclu-
sion favorable to it should be drawn from the
fact of the making of reports in December of
1929.

It is difficult to follow the reasoning. If the

sales so reported occurred after the suits were filed, and knowledge of them could be imputed to these plaintiffs, perhaps an appropriate issue could have been presented in a supplemental pleading, but none was so made.

It is true that the books of the licensee were open to the plaintiffs' inspection, which means that, if efforts had been made to police the licensee, the sales made in February of 1929, would have come to light promptly, instead of
4937 two months later when the installation in Allentown first came to the plaintiffs' notice. That probably means only that these suits would have been filed that much sooner.

There is nothing in the evidence which tends to show that the plaintiffs, or their licensing agent, the Radio Corporation, prior to the filing of these suits, received royalties from the American Transformer Company, with knowledge that they were paid on account of sales of amplifiers to the defendant, which had been made contrary to the terms of the license, and for use of the
4938 devices in violation of the notice attached to them.

Had such a showing been made, a serious issue of estoppel or acquiescence would have been present, but, in the absence of evidence to that effect, it is unnecessary to discuss its probable effect upon the plaintiffs' cause.

The next argument of the defendant is that the charge of infringement does not lie, because its purchase of the tubes, as one of the two elements in the combination required to be established for the completion of the patented device, necessarily permitted it to make the only possible use of the tubes of which they were capa-

ble. In other words, that the tubes were designed, for instance, to be employed only as elements in the circuit of the power circuit patent of Arnold No. 1,329,283, and their use, as such, cannot constitute an infringement of that patent.

This loses sight of the fact that the tubes could be so attached, and the circuit could function in the hands of the defendant, as permitted by the terms of the notice attached to the amplifiers, namely, for experimental or radio amateur use. 4940

It is for use in *excluded* fields, that plaintiffs sue.

The defendant relies upon *Edison Electric Light Co.* v. *Peninsular Light, Power & Heat Co.*, 101 Fed. 31, and *Thomson-Houston Electric Co.* v. *Illinois Telephone Const. Co.*, 143 Fed. 534.

In the former, the electric equipment involved was held to be subject to an implied license to use in connection with the plaintiff's inventions and there was no notice of any contrary restriction. The court says: "It is evident that the extent of an implied license must depend upon the 4941 peculiar facts of each case." The facts there present were indeed remote from those now under examination; as were also the facts in the second case.

The case of *General Electric Co.* v. *Continental Lamp Works, Inc., supra,* passes upon a similar contention concerning the lamp bases there involved, as follows:

> "The sale of an element of a patented combination does not necessarily imply license to use the whole combination. There is always a question of what is a fair inference from the transaction."

After quoting from Judge Lurton's opinion in the *Edison Electric Light Co.* case, *supra*, the court continues:

"We accept this statement of the law, and with it as a guide we think the parties here did not intend that an implied license be granted. The mere sale imports no license, except where the circumstances plainly indicate that it did, or except where good faith
4943 required it, or where it cannot be doubted that the vendee understood that they were getting a license. We are convinced that, in view of what was written in the terms of sale, there was no justification for the vendee's being thus persuaded. *Natl. Cash Register* v. *Grobet*, 153 Fed. 905, 82 C. C. A. 651; *Thomson Co.* v. *Ill. Tel. Const. Co.*, 152 Fed. 631, 81 C. C. A. 473; *Montross* v. *Mabie* (C. C.), 30 Fed. 234. We find nothing in the conduct or language which would justify the appellees to be led to any course of conduct
4944 justifying their use of the patented lamp in connection with these bases. The bases were capable of non-infringing uses, and the notice on its face was intended to warn against the use by infringement of the patent in suit."

See also:

Popsicle Corporation v. *Weiss*, 40 Fed. (2d) 301 at 302;

Nachman Spring-Filled Corporation v. *Kay Mfg. Corporation*, 78 Fed. (2d) 653 at 657.

It is concluded that this defendant cannot avoid the issue of infringement on the theory stated, because it has not brought itself within the first case upon which it relies. This defendant is clearly shown to have had actual knowledge of the restricted use of the tubes when combined with the rest of the amplifier; and the combination of the two elements constituting the amplifier was capable of use by a purchaser from the licensee in fields to which the restrictions did not apply. 4946

The final ground of defense presents the question of validity of the various patents upon which plaintiffs rely. All of them have to do either with the three electrode vacuum tube or the circuit organization of which that tube forms a part.

It will be convenient to consider the patents in the following order:

Lowenstein, No. 1,231,764 (Claims 1, 2, 4, 5, 6, 7):

These claims were held valid and infringed 4947 in *Western Electric Co.* v. *Wallerstein*, 60 Fed. (2d) 723. In that case the importance of the negative grid bias in the three electrode tube is explained; that is to say, that the grid must not be permitted to become more positive than the filament so that the traffic or flow of the electrons given off by the filament to the plate may not be diverted even in part to the grid; in other words that there may be no current in the input or grid circuit, for, if that were permitted, a loss of energy would result and that in turn would contribute distortion to the process of relaying and amplifying the incoming signals.

See also *Radio Corporation of America* v. *Majestic Distributors*, 6 Fed. Supp. 87, at page 89, for a brief outline of the art involved as it developed subsequent to the time of the Fleming valve.

The defendant's brief asserts that the prior art upon which the defendant relies to defeat Lowenstein is the same as that which was before the court in the *Wallerstein* case, which obviously relieves this court of the duty of re-
4949 examining the subject. Even if there is a present disposition to be more critical than formerly in recognizing the presence of invention (*Technidyne Corporation* v. *McPhilben-Keator, Inc.*, 72 Fed. [2d] 242) in kindred fields, revision of the adjudication of this patent does not pertain to the court of instance.

Accordingly the Lowenstein patent in suit is held to be valid and to have been infringed.

Mathes, No. 1,436,754:

This patent has to do with the tube and re-
4950 lates to sources of direct current potential for the input circuit. Claim 8 alone is involved, namely:

> "8. In an electric translating circuit, an electron discharge device having a cathode, an anode and an auxiliary electrode, said auxiliary electrode and said cathode being in the input circuit of said tube, a source of current connected to said cathode, a resistance, a circuit containing said cathode, said source and said resistance in series, said resistance being also included in the input circuit of said tube in such a manner

that the potential of said auxiliary electrode is normally maintained lower than any part of said cathode by an amount substantially equal to the drop in said resistance, said cathode being rendered thermionically active by current flowing in said series circuit."

Mathes imposes the negative bias on the grid by interposing a resistance between the negative terminal of the battery C (which causes the filament to discharge electrons) and the grid; 4952
this resistance causes the grid to be negative in potential with relation to the anode by the drop in potential across the resistance.

In other words, the C battery of Lowenstein is replaced by the resistance employed by Mathes.

This claim was not before the court in the *Wallerstein* case but claim 25 was, which is not here involved. That claim related to means for compensating for fluctuations in the potential of the output circuit. In the course of that
opinion, the court said, at page 732: 4953

> "The use of the resistance as a means for effecting grid bias was invented shortly before Mathes' application."

That expression occurs in the discussion of claim 25 and apparently was not necessary to its adjudication. Whether it is binding upon this court depends upon whether it involves judicial appraisal of the prior art here relied upon.

It is thought that the reference to "Colpitts and Arnold," referred to at the close of the paragraph from which the quotation is taken,

means Arnold, No. 1,504,527, and *Colpitts, No. 1,128,292,* and neither patent is relied on by the defendant in this case to establish art prior to Mathes.

The defendant does rely principally on *Arnold, No. 1,129,942* and *Arnold, No. 1,129,943.* The disclosures therein are substantially alike, and the argument of counsel had largely to do with the first-mentioned. Apparently that patent was cited by the Examiner who passed upon Mathes'
4955 application, which was allowed over it for the reason that Mathes urged that the Arnold patent "uses a separate battery in the case of each tube for supplying the grid with the proper potential."

The former patent is typical of the art upon which defendant relies, and alone will be discussed. In figure 5, the audion tubes, according to the testimony, are connected in series and the filament electrodes are heated from a common source, battery 12. The grid electrodes of the second and third tubes are provided with
4956 means for maintaining them negative with respect to the filament, namely, C battery 11, resistance 14, and the resistance of the filament of the first tube. It is that resistance upon which the defendant relies to demonstrate that it was known to the art that any resistance in the input circuit would impress a negative bias upon the grid in that circuit. The question for decision, therefore, is whether it was known on October 23, 1916, when the Mathes application was filed, that the presence of resistance in the input circuit would accomplish the negative bias required for the efficient operation of the three

electrode vacuum tube as an element in an amplifier.

This Arnold application was filed May 28, 1914, and the invention was said to relate to the use of repeaters generally and of vacuum discharge repeaters more particularly as amplifiers, without transformers. The specifications seem to refer to the desirability of excluding transformers from the circuit, particularly where amplification is desired in circuits of a low impedance. It is said that audions of the usual 4958
type "may be so constructed that, without the use of transformers, they will step up the input voltage of either direct current or alternating current of any frequency in one step as much as 30 times its original value, or in 2 successive steps to as much as 500 times its original value." A step down of the input voltage is also possible where a high current and low voltage output is desirable. It is said in connection with figure 4: "The batteries 11 are preferably of such value as to make each of the grids 3, 3 and 7 normally about five volts negative with respect 4959
to its adjacent filament."

The claims of the patent should be read in connection with the specifications and, when this is done, it will be perceived that the invention claimed was not that asserted by Mathes, and it would seem that the value of the arrangement whereby the grids were maintained negative with respect to the filament was not recognized or discussed as a desirable end in itself.

It is testified for the plaintiffs that Mathes has the advantage "that if the battery system of the tube fluctuates, as for example by charg-

ing as illustrated in fig. 1 of the drawings, the bias is made to vary as the grid current varies."

It is not denied that battery 11 in figure 5 of Arnold No. 1,129,942 must function in order that the grids of the second and third tubes may be negative; that is the necessity which gives rise to the presence of that battery. It must be concluded, therefore, that the negative bias is obtained from that battery and not as the result of the resistance heretofore referred to.

4961 The defendant's brief seeks to avoid the testimony of Mr. Waterman, the plaintiffs' expert on this subject, by arguing that, if the circuit connection of Arnold produces a negative potential on the grid electrode, it is not important "whether or not additional instrumentality such as batteries, etc., may be employed to magnify or raise to a greater degree the negative potential applied thereto." The court must rely upon testimony rather than argument and, as the presence of the negative potential is accounted for by the presence of the battery 11 rather than

4962 by the resistance of the first tube, it is thought that Arnold did not teach that which is claimed as the Mathes invention, and since there is no testimony to the effect that what Mathes accomplished was the adaptation of a mere expedient which any electrical engineer would sooner or later be expected to devise in order to eliminate the C battery of Lowenstein, it must be concluded that the Mathes patent does not lack validity for the reason assigned by the defendant.

It should be said that the late Judge Winslow decided that this claim of the Mathes patent was valid in the case of *Radio Corporation of Amer-*

ica v. *J. H. Bunnell & Co.*, 22 Fed. (2d) 847. This conclusion sustaining validity agrees with that of the Examiner in the Patent Office.

Arnold, No. 1,329,283:

This and the five other patents granted to the same inventor which are here involved invite general comment.

De Forest was responsible for adding the grid to the *Fleming* two element tube, and it has been judicially declared (*Western Electric Co.* v. *Wallerstein, supra*) that De Forest "had made 4964
little progress with it as an amplifier prior to 1912." It was about then that he took the device to the Telephone Company. In his patent No. 879,532 (application filed January 29, 1907) covering a three element tube, he said:

> "I have determined experimentally that the presence of the conducting member a, which as before stated may be grid-shaped, increases the sensitiveness of the oscillation detector and, inasmuch as the explanation of this phenomenon is exceedingly complex and 4965
> at best would be merely tentative, I do not deem it necessary herein to enter into a detailed statement of what I believe to be the probable explanation."

In the *Stone and Cabot patent, No. 884,110,* application filed January 4, 1907, having to do with the audion ("a device which is now well known and which has been fully described in a paper by Dr. Lee De Forest published in the Proceedings of the American Institute of Electrical Engineers, October, 1906, p. 719") it is stated:

4966 "We have found that the sensitiveness of the audion, when connected as above described with a closed oscillating circuit, is greatly impaired from causes which are somewhat obscure and which we deem it unnecessary to discuss herein."

Such was the device that in 1912 invited the attention of Arnold and his colleagues in the Research Department of the Telephone Company.

4967 In passing upon the question of validity as presented by these patents now to be considered, it is necessary to bear in mind that the properties of the tube did not easily yield to the efforts made to lay them bare.

Doubtless the explorations involved repeated experimentation and the successive abandonment of many hypotheses, before conclusions could be announced for which responsibility could be assumed.

If it be thought that such studies necessarily exclude the exercise of the inventive faculty with-
4968 in the contemplation of the patent law as now conceived, then all of these patents might well be declared invalid as failing to disclose invention. That is a responsibility which this court is unwilling to assume for the reason that study, research, and experimentation, to yield success, must involve something more than mere persistence; they must be ordered by understanding and enlightened by intuition and insight of so high an order that invention may come from them. If this view is mistaken, correction need not long be delayed.

As to the particular patent under examination, it should be said that the specifications portray

the philosophy of the three electrode electron device more completely than any other document which has been offered in evidence. The proclaimed object is to provide tube constructions by which certain desired characteristics of the amplifier may be secured at will; this is accomplished by proportioning the geometrical and electrical relations of the various elements as explained, which probably means that the necessary relations of the grid, filament and the plate
had been so established as the result of experi- 4970
mentation that the tubes could be organized for definitely understood purposes by following the teaching of the claims.

It is true that Arnold did not originate the three electrode tube and his contribution to the art of amplification of frequencies by its use might be likened to many of those of the late Thomas A. Edison. That is to say, he perfected, developed, and therefore rendered available, the invention of another, which, but for his research and understanding, might not have come to full
fruition. 4971

Of the twenty-five claims stated in the patent, the following are in suit:

> "7. The combination with a thermionic discharge device having a cathode, an anode and a control element, of an input circuit therefor, and an outgoing circuit having impedance and connected to said anode and cathode, said cathode, anode and control element being so spaced that the impedance of said discharge device between said anode and said cathode is of the same order as that of said outgoing circuit."

4972 "10. The combination with a thermionic discharge device having a cathode, an anode, and a grid, of an input circuit connected to said cathode and said grid, an outgoing circuit having impedance and connected to said anode and cathode, a source of electromotive force in said going circuit, and means for impressing a varying electromotive force upon said input circuit, said cathode being placed in immediate proximity to said grid
4973 but out of electrical contact therewith, and said anode being so spaced from said cathode and grid and the said grid being of such coarse mesh that the impedance of said discharge device between said anode and said cathode is of the same order as that of said outgoing circuit."

"13. The combination with a thermionic discharge device having an anode, a cathode, and an impedance varying element, of an input circuit connected to said impedance varying
4974 ing element, a source of variable electromotive force in said input circuit, a source of electromotive force connected to said anode and cathode, and a work circuit connected to said anode and cathode, the impedance of said discharge device between said cathode and anode being of the same order as that of said work circuit."

Specifically, amplification through the employment of this tube could be of the high voltage type or the high current type, whichever was desired. If the ratio of the output current to the input voltage is high, a power tube is the result.

In order to reach the results announced, Arnold recognized that the internal impedance between the plate and the filament had to be equal to the impedance of the work or output circuit. This is called the theory of matched impedances, and it is not claimed that Arnold was alone in recognizing the necessary applicability of that theory to the effectual operation of these amplifying devices.

It is not proposed to recite the minute details of construction of the tube resulting from the 4976 application of the conclusions arrived at by Arnold.

The defendant relies on *Seibt, No. 1,012,456*, *Arnold, No. 1,129,943*, and *Colpitts, No. 1,129,959*, and it refers to *Langmuir, No. 1,558,436*, merely because of a reference to the geometric proportions of the tube in the case of *De Forest Radio Co.* v. *General Electric Co.*, 283 U. S. 664. The patent was not otherwise referred to in the hearing of this cause.

Seibt was not dealing with a vacuum tube. He merely applied to his radio-telephone transmitter 4977 the recognized principle of matched impedances, through the introduction of resistance into the transmitting medium. It is thought that Seibt made no contribution to the art peculiar to the electron discharge device here involved.

Colpitts, No. 1,129,959, is of questionable status as prior art because the application for that patent was not offered in evidence and so the disclosure therein made has not been revealed. The application was filed April 6, 1914, and the testimony in this record with respect to transcontinental telephony experiments is sufficient to indicate invention by Arnold as early

4978 as January 6, 1914. The file wrapper of this patent contains an affidavit verified by Arnold May 1, 1919, to the effect that he disclosed his invention to Pierce prior to April 6, 1914. As Colpitts was not set up as anticipation, it is thus disposed of.

The *Arnold patent No. 1,129,943* was filed May 28, 1914 (serial number 841569). The application for the patent in suit was filed July 30, 1918, but the caption recites that it is a continuation
4979 in part of application, serial number 841567, filed May 28, 1914, and application, serial number 841568, filed May 28, 1914. In other words, these applications all disclose the inventions of the patent in suit, but the claims were for different aspects thereof. These three claims are not for the tube but for the combination of the tube with the circuit. That combination is not disclosed in the prior art cited, and validity can be defeated only if it is concluded that patentable invention did not underlie the disclosure.

Without repeating what has been said here-
4980 tofore, it is thought that the intellectual process which analyzed the properties of and rendered the three electrode tube selectively available for differing purposes, through organizing its elements and adapting their relations to the circuit described, was of such an order that the status of invention should be accorded to it.

Arnold, No. 1,349,252:

The application for this patent was filed March 20, 1916, and renewed May 16, 1918, and is said to affect the method and means for utilizing thermionic currents; the invention relates to these amplifiers and more particularly to circuit ar-

rangements by which what is called the current voltage characteristic is made to have a desired form; an object is "to repeat or amplify electrical impulses substantially without distortion."

The general purpose is thought to be similar to that announced in *Arnold, No. 1,3[illegible],283*, to accomplish the amplification of current in the output circuit without increasing voltage; to bring this about the internal and external impedances of the same order are maintained.

4982 The purpose is here accomplished by inserting a resistance in the output circuit. The simplicity of the device may have suggested the expediency of reciting in the specifications, in a scientific form, a rather complex exposition of the advantages so obtained. There are nineteen claims of which only one is in suit, namely:

> "15. A thermionic repeater having an input circuit and an output circuit, a source of electromotive force in each of said circuits, said output circuit having an impedance, the magnitude of said electromotive forces and said impedance being such as to cause the output current to vary approximately linearly as the input voltage over a portion of the characteristic curve suitable for efficient operation of the said repeater." 4983

The elaboration of presentation lays an atmosphere of mystery about a step which perhaps may not lend itself to simple or direct exposition; probably the principle intended to be announced is that reproduction of the imposed frequencies can be best accomplished without distortion when there are symmetrical relations be-

tween the input voltage and the output current. If the meaning of the subject-matter has been understood, it is difficult to observe in this patent anything lying beyond the recognized necessity for matched impedances. The application of that general principle, as embodied in Arnold, No. 1,329,283, seems broad enough to comprehend or inevitably suggest the device of this patent.

There may be, as plaintiffs urge, sundry fine-
4985 spun scientific distinctions between the teachings of the two patents, but this court has been unable to discover that patentable invention was brought into play by the putting of a resistance in the output circuit to promote efficiency of performance of a thermionic tube organized according to the teachings of the Power Circuit Patent, Arnold, No. 1,329,283.

It is concluded that this patent lacks validity.

Arnold, No. 1,403,475:

This is a division of the original application
4986 filed September 3, 1915, and this application was filed November 11, 1920. It has to do with vacuum tube circuits in which a plurality of vacuum tubes function in tandem; the object is to provide an improved circuit connection between the tubes "whereby fluctuations of current in the output circuit of one vacuum tube may be impressed on the input circuit of another." The claims are Nos. 8, 9 and 10, namely:

> "8. In combination a circuit comprising a resistance and means for producing potential variations across said resistance, a vacuum tube having input electrodes, and con-

nections for impressing said variations on said electrodes, said connections comprising a series condenser.

"9. In combination a circuit comprising a resistance, a source of direct current and means for producing variations in said current, a vacuum tube having input electrodes, and connections for impressing said variations on said electrodes, said connections comprising a series condenser. 4988

"10. In combination, a circuit comprising a resistance and means for producing potential variations across said resistance, a vacuum tube having input electrodes, connections for impressing said variations on said electrodes, said connections comprising a series condenser, and a resistance shunt for said input electrodes."

As explained by Mr. Waterman, the patent and drawings reveal a two-stage device comprised of a detector as the first and an amplifier 4989 as the second, which are coupled "by a resistance capacity coupling in which the coupling resistance is 25" in the drawing. He traced the current and said: "The alternating current in this case, the audio frequency alternating current, flows from the plate across the filament; thence through the condenser 24 and through the resistance 25 back to the plate. The flow of this current in the resistance 25 creates a difference of potential between the ends of the resistance 25 corresponding exactly to the signal, no matter what the frequency. This characteristic of

the resistance with the voltage across it is independent of the frequency."

The advantage of the resistance capacity coupling is this independence of frequency over "the whole range of voice frequeney handled with practically identical efficiency."

This device permitted the coupling as explained, between a succession of tubes in such a manner that distortion of frequencies was avoided and they were passed on from tube to
4991 tube equally amplified. The record does not indicate any other method whereby this result is accomplished. As a practical matter, the value is particularly recognized in the quality which permits the passing on from one tube to another of very small currents or energies, and the importance of this in the motion picture industry is obvious.

The defendant argues that there was an abandonment of the original claim and that the device was anticipated in Arnold No. 1,129,942. What has been said with reference to the divi-
4992 sional nature of this application from the original which was filed September 3, 1915, disposes of the first objection. As to the second, the issue comes down to this: Does the Arnold patent relied on by the defense (which had for its purpose the exclusion of transformers from amplifiers) disclose a resistance capacity coupling? The defendant's expert, when comparing the two patents, used the following expression: "The only essential difference between this arrangement (referring to Arnold No. 1,129,942) and that shown by the patent in suit is in the substitution of a resistance, No. 25, by the reactance 17, in patent 1,129,942." Since the defendant's

expert regards the difference as essential, it is perhaps unnecessary to pursue this argument further.

It seems that reactance results from the presence of an induction coil or condenser and constitutes a definite kind or form of impedance. The plaintiffs' evidence is persuasive to the effect that the essential difference between the two kinds of coupling is that the earlier one which employs inductance admits of the presence of
that form of impedance known as reactance; this 4994
is avoided by the employment of the resistance capacity coupling of the patent whereby frequencies are faithfully reproduced in the successive tubes of the circuit.

It results that this patent must be deemed valid and infringed.

Arnold, No. 1,448,550:

Application filed February 3, 1919, granted March 13, 1923, covering thermionic amplifier circuits.

The application reveals that it is a continua- 4995
tion in part of application, serial No. 59210, filed November 2, 1915, and of application, serial No. 48873, filed September 3, 1915. The defendant asserts in its brief that the plaintiffs made no effort to identify the part constituting continuance; it is not thought that the burden rested upon them to do so.

The invention relates to repeater circuits in which the tube is employed "for receiving comparatively weak incoming impulses and for transmitting them in the same form or in a modified form but with amplified energy."

Apparently this device was developed in con-

nection with repeaters for transcontinental telephony and the patent discusses the high impedance between the grid and the filament; it is said that, when the grid is under negative bias, this impedance is of the order of infinity, because no electrons can flow from the filament to a negative grid.

Apparently this is the price that is paid for the imposition of the negative bias to the grid.

There are two claims in suit:

4997

> "1. The combination of a vacuum discharge repeater of the three-electrode type, an inductive coil conductively connected to the input electrodes of said repeater, and a conductive impedance in shunt to said coil."
>
> "12. The combination of a line, an amplifier in circuit therewith having an input impedance which is practically infinite, and a shunt between said line and said amplifier having an impedance of the order of 500,000
> 4998 ohms."

From what is presently understood, the object is to modify the effect of the high impedance from an infinite to a finite value. The practical object resulting from the circuit arrangement of the patent is the avoidance of resonance caused by conditions which are presently so little understood that it is necessary to quote Mr. Waterman's testimony to avoid judicial distortion. Referring to the transformer in the circuit between which and the vacuum tube the resistance is inserted, he says: "Now, it is possible for that transformer acting with the ca-

pacity of the tube to get into a state of * * *
resonance wherein at a particular frequency the
impedances due to the inductance and to the tube
capacity disappear and the transformer becomes
enormously receptive to frequencies of that
value, so that it is possible for the resonant ef-
fect produced to pick out and exaggerate one
frequency * * *. The transformer tends to work
at a particular frequency and all the powers of
an electric designer have to be exercised to get
a transformer which will have broad frequency 5000
characteristics. The tendency resulting from the
feed back just mentioned is because the trans-
former is to be selected for particular frequen-
cies. All of these effects are cured or minimized
by putting across the secondary of the input
transformer a resistance chosen of proper value
to effect the cure of the particular defect ex-
perienced.

"The tube then looks to the transformer and
the incoming line like a definite load of that
value selected with a desired end to be attained
and used, and this patent therefore is known as 5001
the Definite Impedance Patent. * * * The re-
sistance serves to prevent reflection by absorb-
ing the energy that might otherwise be reflected.
It serves to prevent or minimize the resonance
effect by absorbing the energy which would
otherwise go into the resonance phenomenon. It
prevents or minimizes the effect of feed back
from the plate to the input circuit, by again ab-
sorbing the energy fed back."

The defendant relies upon certain earlier patents and particularly alleged complete anticipation, lack of patentable novelty, and a double patenting.

Possibly the object accomplished by the circuit arrangement disclosed, may be a preliminary step to the ultimate matching of impedances, but nothing in the testimony or the patent so discloses. The showing apparently is that the input impedance must be transposed from an infinite to a finite aspect in order that the tube may function, and Arnold seems to have been the first, in point of time, to devise a method for meeting this known requirement; the problem
5003 was recognized as an obstacle to transcontinental telephony, and the repeater development necessary thereto; Arnold's solution of the problem, as related by the witness Kendall, is convincing as to dates, because he was fortified by records.

The earliest filing date named in any of the five patents upon which defendant relies is April 6, 1914, as to Colpitts No. 1,129,959.

Kendall is a persuasive witness to carry Arnold's date of invention to the early part of March, 1914. It should be noted that one of the other patents relied on, that of Van der Bijl,
5004 filed August 15, 1915, was granted to one who was then an associate of Arnold in the research work to which reference has been made.

Circuits employing the repeater embodied in this invention were in service in Pittsburgh experimentally on March 10th and 11th, and in Philadelphia on March 23, 1914. This testimony is to the same effect as the affidavits of Arnold appearing in the various file wrappers as to his dates of invention.

It is concluded that the defendant cannot rely upon the art as shown to deprive Arnold of priority of invention.

As to the assertion that claim 12 is devoid of

patentable novelty "as merely being for specific electrical values, any choice of which being exhausted by the teachings of the prior art that the shunted impedance may be varied to any desired value," it is to be said:

As to the teachings of the prior art as alleged, it is thought that there are none; in view of which the mere assignment to the impedance of the order of 500,000 ohms in claim 12 is probably not so specific as to render the claim in-
valid. 5006

So far as the assertion of double patenting is concerned, attention is directed to claims 16, 17 and 24 of Arnold patent No. 1,329,283, where it is said that the same invention in different language is disclosed. Claim 16 is cited as an illustration. This is the Power Circuit Patent, *supra*, and claim 16 reads as follows:

> "16. Means for amplifying energy without substantial voltage amplification, comprising a vacuum discharge tube having an
> input and an output circuit, a source of 5007
> variable energy to be amplified connected in said input circuit, and a translating device to which the amplified energy is delivered connected in said output circuit."

It is argued that the words "a source of variable energy to be amplified connected in said input circuit" embodied the concept of an impedance connected in shunt in the input circuit and thus there is double patenting. It is thought that the expression quoted from the earlier Arnold patent differs from the claim relied upon, in that the reference to a source of variable energy in

Arnold No. 1,329,283 may mean a number of things, while the device in suit is limited to a high impedance connected across the input transformer. It may be that the scope of the earlier patent is broad enough to envisage what is claimed in the later one, but certainly the invention stated in it cannot be said to involve the same conception as that portrayed in the Power Circuit Patent; in other words, the defendant has failed to meet the requirements to prove
5009 double patenting. The defense has been considered on its merits in spite of the fact that it was not pleaded. The instant patent is held to be valid and infringed.

Arnold, No. 1,465,332:

This is a second divisional application. The original was filed September 3, 1915, and the first divisional application thereon was filed March 26, 1919, and the second, upon which this patent was granted, was filed August 28, 1920. It relates to arrangements for supplying space cur-
5010 rent to vacuum tube amplifiers and an object is to provide means whereby a plurality of vacuum tubes to be used as repeaters or amplifiers may be supplied with space current from a single source, but in such a manner that current changes in one tube due to signals being repeated cannot be impressed upon another tube through said source.

Stated plainly, what is embodied is a circuit arrangement including a plurality of tubes each of which amplifies into the following tube; operation from a common source of space current is rendered possible and at the same time the amplifying current flowing in the tube is not per-

mitted to affect the circuit of the preceding tube through regeneration so as to distort the signals.

As pointed out in *De Forest Radio Co.* v. *General Electric Co.,* 283 U. S. 664 at 671, the output current depends on the intensity of the electron stream from the filament to the plate, which in turn is governed by the voltage of the current passing to the filament; if that is intense enough to "force all the electrons emitted by the filament to pass from filament to plate, increase in the voltage at the filament will not 5012
produce an increase in current in the loud speaker circuit and the tube is then said to be saturated." As successful operation of the tube depends upon the response of the loud speaker current to changes in voltage effected by the voice or input current, the tube is most efficiently operated at a voltage of a range below saturation, and a current within this range is known as the 'space current'."

The space current is supposedly of dual constituency, namely, the direct current generated by the plate battery, upon which is superimposed 5013
the alternating voltage carrying the incoming signals.

In the employment of a single source of current to supply the plate electrodes where there are a number of tubes in an assembly, some of the circuit is common to all of the tubes, which leads to interaction between them, which will be transmitted to all of the tubes.

A weakness of the common source system was that it provided a means for later tubes in the assembly to feed back into the earlier ones, in turn setting up regeneration. If that takes place, the amplified signals in one tube flow in

the plate circuit of the preceding tube, and that will affect the input circuit of the tube from which it emerged. To overcome this tendency, the filter system of the patent in suit was devised. Claims 1, 3, 5, 8, 10 and 11 are involved:

"1. In combination, a plurality of vacuum tube repeaters, a common source of space current for said repeaters, the circuit between one of said repeaters and said source
5015 comprising series inductance, and a path comprising capacity bridged across said circuit between said source and said repeater."

"3. In combination, a plurality of vacuum tube repeaters, said repeaters being connected in multiple to a common source of space current, and means to prevent alternating currents from one of said repeaters from flowing in the portion of the space current circuit common to said repeaters."

5016 "5. In a multi-stage amplifier, a plurality of vacuum tubes connected in tandem, a common source of space current for said tubes, branch circuits connecting said source and said tubes, and a filter comprising series inductance in one of said circuits and a path containing capacity bridged across the circuit between one of said tubes and said source."

"8. In combination, a plurality of vacuum tube translating devices, a common source of current for energizing said tubes, and a path comprising capacity bridged across

each of the circuits connecting said tubes to said source."

"10. The combination in an amplifying system of a series of electron discharge amplifiers connected in cascade, each of said amplifiers having plate and grid circuits, a common source of current for supplying current to the plate circuits of all of said amplifiers in succession from the last to the first of said amplifiers, and filter connections between successive amplifiers of the series." 5018

"11. The combination in an amplifying system of a series of electron discharge amplifiers connected in cascade, each of said amplifiers having plate and grid circuits, a common source of current for supplying current to the plate circuits of all of said amplifiers, and filter connections between successive amplifiers of the series."

It has been explained that the filters make it possible to employ the common plate supply of direct current for all the tubes without sacrifice of the alternating or signal current constituency of the space current in the output circuits. The demonstration of the philosophy of this circuit arrangement offered on behalf of the plaintiffs is not questioned, and it is common ground that the desired purpose necessarily employs resistance for dealing with direct current and impedance or reactance for the alternating current. As the defendant's counsel stated (speaking of another patent): "In the output circuit of a vacuum tube there is both direct current and alternating cur- 5019

rent. You have to have a path of travel for both, a path of travel for the alternating current is through the condenser shunting around resistance 15 (Weagant No. 1,384,108) to the condensers for the reactance, depending on their value and impedance for alternating current."

As defendant must be taken to have conceded the adequacy of the device of this patent to accomplish its avowed purpose, the only possibly successful method of attack upon the patent was
5021 to assert that it had been anticipated, as the defendant says, by Arnold No. 1,129,942. Figure 6 of that patent does present a common battery for all the plates but, as Arnold deposed in the file wrapper of this patent, in order to avoid the same objection made by the Examiner, that was an immaterial element of that patent. The further point of resemblance is said to be the inductance coils shown in figure 6 which are coupling elements according to the defendant's expert, Cloud.

His statement is this: "A simple statement
5022 would be in this case, by means of a choke we hold back alternating current frequency and by means of a condenser we by-pass them (*sic*) in the direction we wish them to go. We keep them out of one portion of the circuit and pass them into another."

The plaintiffs' testimony, which is uncontradicted, as to this narrow issue, is that there is no such inductance shown in the prior Arnold patent *as a filter means to prevent oscillation in the system.* The argument is made that the office of the inductance coils 17 in figure 6 of Arnold No. 1,129,942 is to permit alternating current to pass through them while the impedances

21 and 28 in this patent are availed of to prevent that very thing. Mr. Waterman states it this way:

> "And the interposition of the choke or inductance coil 28 is for the purpose also of imposing a difficulty in the path of the alternating current from flowing in the wire that leads back to the battery."

It appears that coil 21 is also a choke or inductance coil. The importance of these two elements for the purpose stated is somewhat minimized by the following passage from the same witness' deposition: 5024

> "Those are the means adopted to make practical the operation of the tube from a common source. It is commonly found that the mere use of the condensers is enough, or even one condenser is enough, sometimes just one choke is used, maybe in either of the positions shown; sometimes the whole combination is used, according to the severity of the conditions that are imposed." 5025

It will thus be seen that, as to these particular choke coils, the patent can scarcely be regarded of major importance, but it is not deemed to have been sufficiently discredited by the testimony offered for the defendant, as contrasted with argument, to overcome the presumption of validity which is fortified by the prior examination of the cited patent in the Patent Office; allowance was had over that patent, as to the effect of which, to fortify the presumption of val-

idity, see *Ensign Carburetor Co.* v. *Zenith-Detroit Corporation*, 36 Fed. (2d) 684.

Validity is found.

Arnold, No. 1,520,994:

Original application filed September 3, 1915, of which this is a division, filed March 28, 1919.

This patent has to do with an arrangement
for a method of varying the ratio of amplifica-
tion of an electron discharge amplifier, and the
purpose is accomplished (without varying the
5027 impedance presented by the amplifier as a whole
to the impulses which are to be amplified) by
the use of an impedance shunted across the ter-
minals of the secondary of the transformer used
to step up the voltage of the incoming currents.

The filament is connected to one end of this
impedance and a connection is made from the
grid by means of an adjustable contact to a de-
sired point on the impedance; by this means the
proportionate part of the potential drop across
the impedance which is applied between the grid
and the filament varies the amplification in the
5028 output circuit. Claims 1 and 4 are involved,
namely:

> "1. In combination, an electron discharge relay comprising an anode, a cathode and a control electrode, a circuit containing a source of alternating current electric impulses to be relayed, an impedance in shunt to said source, and means comprising a contact movable along said impedance for effectively connecting said control electrode and said cathode across an adjustable proportion of the whole of the said impedance."

"4. The combination of an incoming line, an amplifier having a cathode and an anode, means for supplying a space current between said electrodes, said amplifier having a grid electrode for controlling such space current, means for making said grid negative with respect to said cathode, and means between said line and the input electrodes for making the impedance of said amplifier as seen from said line substantially of a constant value, said last mentioned means com- 5030
prising a potentiometer arrangement including an impedance and a contact movable along said impedance for varying the voltage supplied to said input electrodes."

There is no dispute as to the nature of the de-
vice or the way it operates. The incoming sig-
nal enters at one end of the amplifier and as am-
plified it emerges from the other end. The con-
rol of the latter may be desired through the em-
ployment of a device which does not disturb the
operating characteristics of the entire apparatus 5031
o that accuracy of reproduction of the incoming
ignal is preserved. This patent accomplishes
he purpose by means of the potentiometer, volt-
ge being driven off the voltage plate to the
rid of the second tube. The resistance is con-
ected across the secondary of the intermediate
ransformer and "the variable quantity of the
oltage expended in that resistance is applied to
he grid, the grid is negatively biased and there-
ore its control has no effect whatever on the
ircuits to disturb their performance."

The foregoing paraphrase and quotation are rom Mr. Waterman's testimony. Elsewhere he

refers to the potentiometer as here used as follows: "It is commonly known also as a voltage divider."

The device permits control of the alternating power voltage of the secondary of the intermediate transformer which is distributed along resistance 25; by removing the point 26 (the potentiometer) "any part of it may be taken off because the filament connection is fastened to the bottom, therefore, if point 26 were to be cleared
5033 at the bottom end, then no voltage at all would be taken to the grid and that would have no output. If we moved it to the top, then, we would have maximum output. Any output between can be attained."

The matter to be decided comes down to this: Did the application of a potentiometer, which the plaintiffs' testimony shows to have been one of the oldest of electrical tools, to this particular use, involve patentable invention?

It is thought that the answer should be in the negative. It is probably true that this particular
5034 use of this well known device as an adjustable contact to high impedance across the input circuit, the negative grid bias being present, did not happen to occur to others skilled in the art at the time that this patent was applied for, and yet the entire testimony creates the impression that it merely involved the selection of a well known means to accomplish a necessary purpose which falls short of indicating the exercise of the inventive faculty. For this reason, it is concluded that the patent lacks validity.

There remains for consideration the contention that five of the Arnold patents are invalid because the evidence discloses that transcontinen-

tal telephone service available to the public in January of 1915, involved the use by the plaintiffs of the inventions described in some or all of these patents, and that the latter were granted more than two years subsequent to this commercial use and therefore section 4886 of the Revised Statutes constitutes a statutory bar to their validity. It is said that the plaintiffs have offered no evidence from which the conclusion could be drawn that this delay is excusable.

The patents so challenged are: 5036

Arnold, No. 1,329,283 (Power Circuit) application filed July 30, 1918.

Arnold, No. 1,403,475 (Resistance Capacity Coupling) application filed November 11, 1920.

Arnold, No. 1,448,550 (Definite Input Impedance) application filed February 3, 1919.

Arnold, No. 1,465,332 (Common Plate Supply) application filed August 28, 1920.

Arnold, No. 1,520,994 (Gain Control) application filed March 28, 1919.

The argument is mistakenly directed as to members 2 and 4, the Resistance Capacity Coupling and the Common Plate Supply patents, because the testimony does not disclose that they were employed in the transcontinental telephone service. 5037

As to the remaining three:

Arnold, No. 1,329,283, the Power Circuit patent, was not a divisional application but a continuing application seemingly disclosed in two earlier filed applications pending with the continuing application, namely, serial No. 841,567 filed May 28, 1914, and serial No. 841,568 filed May 28, 1914. The caption of this patent so discloses.

Arnold, No. 1,448,550, the Definite Input Impedance patent, recites that it is a continuation in part of application serial No. 59,210 filed November 2, 1915, and of application serial No. 48,873 filed September 3, 1915, said to disclose the invention.

The defendant asserts that there is an implied abandonment of the earlier filed application, by which assertion it seeks to support its argument that the statutory bar applies. On this subject
5039 Walker, 6th Edition, page 248, reads:

> "When the two applications are continuous the two years' public use or sale which may avoid the patent must be reckoned from the presentation of the first application, and not from the filing of subsequent applications or amendments." (Citing *Hayes-Young Tie Plate Co.* v. *St. Louis Transit Co.*, 137 Fed. 80; *Victor Talking Mach. Co.* v. *American Graphophone Co.*, 145 Fed. 350; *Corrington* v. *Westinghouse Air Brake Co.*, 178 Fed. 711.)

5040
The citations seem to fortify the text.

See also:

> *American Tri-Ergon Corporation* v. *Paramount Publix Corporation*, 71 Fed. (2d) 153, at 157.

Arnold, No. 1,520,994, the Gain Control patent: The specifications state that this is divided out of an application serial No. 48,873 filed September 3, 1915, which apparently discloses the subject-matter.

The important aspect of the argument lies in the fact that it is not supported by any equitable

onsiderations because the public use to which he defendant refers is the plaintiffs' own use, not that of any other inventor.

Naturally the defendant did not use any of hese inventions until the year 1929, and the de-ision upon which it relies, namely, *Westing-house Electric & Manufacturing Co.* v. *Jeffrey-DeWitt Insulator Co.*, 22 Fed. (2d) 277, is wholy unlike this controversy in that most important espect. It is true that the court there says that ecent decisions of the Supreme Court have mod- 5042
ied the earlier rule respecting a divisional pat-nt, which rule was that in the absence of laches r estoppel of intervening rights, the divisional atent related to the date of filing the original pplication. The Supreme Court, however, in *Vebster Electric Co.* v. *Splitdorf Electrical Co.*, 64 U. S. 463, at 471, in commenting upon the ule of decision in *Chapman* v. *Wintroath*, 252 . S. 126, says:

> "But a reading of the entire opinion dem-onstrates that this conclusion (that a hard 5043
> and fast time limit of two years is to be applied in every case of a divisional application) is erroneous. The Court proceeds to say that divisional applications are not to be dealt with in a hostile spirit, but are to be 'favored to the extent that where an invention clearly disclosed in an application * * * is not claimed therein but is subsequently claimed in another application, the original will be deemed a constructive reduction of the invention to practice and the later one will be given the filing date of the earlier, with all of its priority of right.'

5044 > * * *; and, while it is not said in terms, the plain import of the citation of and reliance upon these cases (those cited) is that the effect of the two years' delay, as recognized in those cases, may be overcome where it 'is accounted for and excused by special circumstances, which show it to have been not unreasonable'; and, properly understood, there is nothing in the opinion to the contrary.

5045 > "Our conclusion, therefore, is that in cases involving laches, equitable estoppel or intervening private or public rights, the two-year time limit *prima facie* applies to divisional applications and can only be avoided by proof of special circumstances justifying a longer delay. In other words, we follow in that respect the analogy furnished by the patent reissue cases."

The statute upon which the defendant relies was not involved in the *Webster Electric Co.*
5046 case, but it was referred to for the sake of analogy.

Clearly the court considers the equitable aspect of any such controversy, and there is authority which will here be followed, to the effect that the plaintiffs' own public use more than two years prior to the date of the filing of a divisional application, but within two years of the date of the application from which the division was made, does not call into operation the statute upon which the defendant relies. That authority is *American Chain Co.* v. *Franklin New York Co.*, 34 Fed. (2d) 551, in which there is a quotation from Judge Hough's opinion in the

case of *American Laundry Machinery Co.* v. *Prosperity Co.*, 295 Fed. 819, which seems to furnish a complete answer to the defendant's position. The *American Chain Co.* case, has not been adversely affected by any subsequent decision.

Decree for the plaintiffs as prayed, to be settled on notice.

If the foregoing is not deemed a sufficient compliance with Equity Rule 70½, Findings may be settled in connection with the decree in accordance with the foregoing. 5048

M. W. B.,
U. S. D. J.

Decree (Equity No. 50-175).

UNITED STATES DISTRICT COURT,

SOUTHERN DISTRICT OF NEW YORK.

WESTERN ELECTRIC COMPANY, INCORPORATED, ELECTRICAL RESEARCH PRODUCTS, INC., and AMERICAN TELEPHONE AND TELEGRAPH COMPANY, 5049
Plaintiffs,
against
GENERAL TALKING PICTURES CORPORATION,
Defendant.

In Equity No. 50-175.

This cause having come on to be heard at this term and was argued by counsel; and thereupon,

upon consideration thereof, it is ORDERED, ADJUDGED and DECREED as follows:

1. That plaintiff, American Telephone and Telegraph Company, is the owner of the following Letters Patent in suit:

Name	*Number*	*Granted*
Arnold	1,329,283	Jan. 27, 1920
Arnold	1,349,252	Aug. 10, 1920
5051 Arnold	1,448,550	Mar. 13, 1923
Arnold	1,520,994	Dec. 30, 1924

2. That plaintiffs, Western Electric Company, Incorporated, and Electrical Research Products Company, Inc., are exclusive licensees under each of said Letters Patent in the sound picture field and are proper parties plaintiff.

3. That claims 7, 10 and 13 of said Letters Patent No. 1,329,283 and claims 1 and 12 of said Letters Patent No. 1,448,550, are good and valid
5052 in law.

4. That defendant, General Talking Pictures Corporation, has infringed each of the said claims of said Letters Patent Nos. 1,329,283 and 1,448,550 by leasing to motion picture theatre owners in the United States, for use in reproducing talking motion pictures, vacuum tubes and vacuum tube amplifiers, said vacuum tubes and vacuum tube amplifiers being identified and diagrammatically illustrated in Plaintiffs' Exhibit 2 in evidence.

5. That the said acts of the defendant were not licensed under any of said Letters Patent in

suit as alleged in either paragraphs 6 or 7 of the answer, or as otherwise contended by the defendant in this case.

6. That a perpetual injunction issue out of and under the seal of this Court enjoining and restraining said defendant, its associates, agents, attorneys, servants, workmen, employees and each of them, and all those in privity therewith, under the pains and penalties which may fall in
case of disobedience, from infringing or con- 5054
tributing to the infringement of claims 7, 10 and 13 of said Letters Patent No. 1,329,283 and claims 1 and 12 of said Letters Patent No. 1,448,-550, and particularly from doing the acts held to be an infringement in paragraph 4 hereof, and from otherwise infringing or contributing to the infringement of said Letters Patent.

7. That defendant account for and pay over to plaintiffs all gains and profits that have accrued or been earned or received by the de-
fendant by reason of its said infringement, and 5055
all gains and profits that would have accrued to the plaintiffs but for the unlawful acts of the defendant, and all damages plaintiffs have sustained thereby; that this cause be referred to Dean S. Edmonds, Esq., a special master of this Court, to take and state an account of said profits, savings, advantages and damages, and to report thereon to this Court; and that the defendant, its associates, agents, attorneys, servants, workmen and employees and each of them, and all those in privity therewith, are hereby directed to attend before the said Master from time to time as required, and to produce such

books, other documents and exhibits as they may be directed to produce, and to submit to such oral or other examination as the Master may direct.

8. That the plaintiffs recover from the defendant three-fourth (¾) of plaintiffs' total costs in this and the other two suits, Equity Nos. 50-177 and 50-178, which were tried with this suit.

5057

9. That claim 15 of said Letters Patent No. 1,349,252 and claims 1 and 4 of said Letters Patent No. 1,520,994, are invalid and void; and the bill of complaint be and the same is hereby dismissed as to said Letters Patent.

Mortimer W. Byers,
United States District Judge
Sitting by Special Designation.

Dated: 10/27/36.

5058 Approved as to form.

(Sd.) Samuel E. Darby, Jr.,
Counsel for Defendant.

(Sd.) Henry R. Ashton,
Counsel for Plaintiffs.

Decree (Equity No. 50-177). 5059

UNITED STATES DISTRICT COURT,

SOUTHERN DISTRICT OF NEW YORK.

WESTERN ELECTRIC COMPANY, INCORPORATED, ELECTRICAL RESEARCH PRODUCTS, INC., and AMERICAN TELEPHONE AND TELEGRAPH COMPANY,
Plaintiffs,
against
GENERAL TALKING PICTURES CORPORATION,
Defendant.

In Equity No. 50-177. 5060

This cause having come on to be heard at this term and was argued by counsel; and thereupon, upon consideration thereof, it is ORDERED, ADJUDGED and DECREED as follows:

1. That plaintiff, American Telephone and Telegraph Company, is the owner of the following Letters Patent in suit: 5061

Name	*Number*	*Granted*
Lowenstein	1,231,764	July 3, 1917
Mathes	1,426,754	Aug. 22, 1922

2. That plaintiffs, Western Electric Company, Incorporated, and Electrical Research Products Company, Inc., are exclusive licensees under each of said Letters Patent in the sound picture field and are proper parties plaintiff.

3. That claims 1, 2, 4, 5, 6 and 7 of said Letters Patent No. 1,231,764 and claim 8 of said Letters Patent No. 1,426,754, are good and valid in law.

4. That defendant, General Talking Pictures Corporation, has infringed each of the said claims of said Letters Patent Nos. 1,231,764 and 1,426,754 by leasing to motion picture theatre owners in the United States, for use in reproducing talking motion pictures, vacuum tubes and vacuum tube amplifiers, said vacuum tubes
5063 and vacuum tube amplifiers being identified and diagrammatically illustrated in Plaintiffs' Exhibit 2 in evidence.

5. That the said acts of the defendant were not licensed under any of said Letters Patent in suit as alleged in either paragraphs 6 or 7 of the answer or as otherwise contended by the defendant in this case.

6. That a perpetual injunction issue out of and under the seal of this Court enjoining and restraining said defendant, its associates, agents,
5064 attorneys, servants, workmen, employees and each of them, and all those in privity therewith, under the pains and penalties which may fall in case of disobedience from infringing or contributing to the infringement of claim 8 of said Letters Patent No. 1,426,754 and particularly from doing the acts held to be an infringement in paragraph 4 hereof, and from otherwise infringing or contributing to the infringement of said Letters Patent.

7. That defendant account for and pay over to plaintiffs all gains and profits that have accrued or been earned or received by the defendant by

reason of its said infringement, and all gains and profits that would have accrued to the plaintiffs but for the unlawful acts of the defendant, and all damages plaintiffs have sustained thereby, that this cause be referred to Dean S. Edmonds, Esq., a special master of this Court, to take and state an account of said profits, savings, advantages and damages, and to report thereon to this Court; and that the defendant, its associates, agents, attorneys, servants, workmen and
employees and each of them, and all those in 5066
privity therewith, are hereby directed to attend before the said Master from time to time as required, and to produce such books, other documents and exhibits as they may be directed to produce, and to submit to such oral or other examination as the Master may direct.

8. That the plaintiffs recover from the defendant three-fourths (¾) of plaintiffs' total costs in this and the other two suits, Equity Nos. 50-175 and 50-178, which were tried with this
suit. 5067

MORTIMER W. BYERS,
United States District Judge
Sitting by Special Designation.

Dated: 10/27/36.

Approved as to form.

(Sd.) SAMUEL E. DARBY, JR.,
Counsel for Defendant.

(Sd.) HENRY R. ASHTON,
Counsel for Plaintiffs.

5068

Decree (Equity No. 50-178).

UNITED STATES DISTRICT COURT,

SOUTHERN DISTRICT OF NEW YORK.

WESTERN ELECTRIC COMPANY, INCORPORATED, ELECTRICAL RESEARCH PRODUCTS, INC., and AMERICAN TELEPHONE AND TELEGRAPH COMPANY, Plaintiffs, against GENERAL TALKING PICTURES CORPORATION, Defendant.	In Equity No. 50-178.

5069

This cause having come on to be heard at this term and was argued by counsel; and thereupon, upon consideration thereof, it is ORDERED, ADJUDGED and DECREED as follows:

5070

1. That plaintiff, American Telephone and Telegraph Company, is the owner of the following Letters Patent in suit:

Name	*Number*	*Granted*
Arnold	1,403,475	Jan. 17, 1922
Arnold	1,465,332	Aug. 21, 1923

2. That plaintiffs, Western Electric Company, Incorporated, and Electrical Research Products Company, Inc., are exclusive licensees under each of said Letters Patent in the sound picture field and are proper parties plaintiff.

3. That claims 8, 9 and 10 of said Letters Patent No. 1,403,475 and claims 1, 3, 5, 8, 10 and 11 of said Letters Patent No. 1,465,332, are good and valid in law.

4. That defendant, General Talking Pictures Corporation, has infringed each of the said claims of said Letters Patent Nos. 1,403,475 and 1,465,332 by leasing to motion picture theatre owners in the United States, for use in reproducing talking motion pictures, vacuum tubes and vacuum tube amplifiers, said vacuum tubes and 5072
vacuum tube amplifiers being identified and diagramatically illustrated in Plaintiffs' Exhibit 2 in evidence.

5. That the said acts of the defendant were not licensed under any of said Letters Patent in suit as alleged in either paragraphs 6 or 7 of the answer, or as otherwise contended by the defendant in this case.

6. That a perpetual injunction issue out of and under the seal of this Court enjoining and re- 5073
straining said defendant, its associates, agents, attorneys, servants, workmen, employees and each of them, and all those in privity therewith, under the pains and penalties which may fall in case of disobedience from infringing or contributing to the infringement of claims 8, 9 and 10 of said Letters Patent No. 1,403,475 and claims 1, 3, 5, 8, 10 and 11 of said Letters Patent No. 1,465,332, and particularly from doing the acts held to be an infringement in paragraph 4 hereof, and from otherwise infringing or contributing to the infringement of said Letters Patent.

5074

7. That defendant account for and pay over to plaintiffs all gains and profits that have accrued or been earned or received by the defendant by reason of its said infringement, and all gains and profits that would have accrued to the plaintiffs but for the unlawful acts of the defendant, and all damages plaintiffs have sustained thereby; that this cause be referred to Dean S. Edmonds, Esq., a special master of this Court, to take and state an account of said profits, sav-
5075 ings, advantages and damages, and to report thereon to this Court; and that the defendant, its associates, agents, attorneys, servants, workmen and employees and each of them, and all those in privity therewith, are hereby directed to attend before the said Master from time to time as required, and to produce such books, other documents and exhibits as they may be directed to produce, and to submit to such oral or other examination as the Master may direct.

8. That the plaintiffs recover from the defend-
5076 ant three-fourths (¾) of plaintiffs' total costs in this and the other two suits, Equity Nos. 50-175 and 50-177, which were tried with this suit.

Mortimer W. Byers,
United States District Judge
Sitting by Special Designation.

Dated: 10/27/36.

Approved as to form.

(Sd.) Samuel E. Darby, Jr.,
Counsel for Defendant.

(Sd.) Henry R. Ashton,
Counsel for Plaintiffs.

Stipulation and Order in Three Suits Re Findings of Fact and Conclusions of Law. 5077

UNITED STATES DISTRICT COURT,

SOUTHERN DISTRICT OF NEW YORK.

WESTERN ELECTRIC COMPANY, INCORPORATED, ELECTRICAL RESEARCH PRODUCTS, INC., and AMERICAN TELEPHONE AND TELEGRAPH COMPANY,
Plaintiffs,

vs.

GENERAL TALKING PICTURES CORPORATION,
Defendant.

In Equity Nos. 50-175, 50-177, 50-178. 5078

It is hereby stipulated and agreed by and between the parties hereto that the opinion of the Court in these cases shall be deemed sufficient findings of fact and conclusions of law, in compliance with Equity Rule 70-½ and RULE XVIII of the Equity Rules of this Court. 5079

SAMUEL E. DARBY, JR.,
Counsel for Defendant.

HENRY R. ASHTON,
Counsel for Plaintiffs.

It is so ordered.

MORTIMER W. BYERS,
United States District Judge.

October 27, 1936.

5080

Supersedeas Order.

UNITED STATES DISTRICT COURT,

SOUTHERN DISTRICT OF NEW YORK.

WESTERN ELECTRIC COMPANY, INCORPORATED, ELECTRICAL RESEARCH PRODUCTS, INC., and AMERICAN TELEPHONE AND TELEGRAPH COMPANY, Plaintiffs, vs. GENERAL TALKING PICTURES CORPORATION, Defendant.	In Equity Nos. 50-175, 50-177, 50-178.

5081

These three causes having come on to be heard on defendant's motion for an order staying the issuance of injunctions and were argued by counsel and thereupon, upon consideration thereof, it is ORDERED

5082 That the issuance of the injunctions provided for in the decrees of this Court be and the same is hereby stayed twenty (20) days from the date hereof; and that providing appeals are duly taken by the defendant from the said decrees to the United States Circuit Court of Appeals for the Second Circuit within the said twenty (20) days, and are regularly prosecuted, the issuance of the said injunctions shall further be stayed until the decision by the said Court of said appeals, upon the conditions (1) that the defendant shall file a bond with adequate surety in the amount of Ten Thousand ($10,000.00) Dollars

conditioned to reimburse the plaintiffs for all costs which may be awarded the plaintiffs in this Court and in the Court of Appeals, and for all profits, gains and advantages and damages which may eventually be adjudged to be due the plaintiffs from the defendant by reason of its infringement of the claims in suit of Letters Patent Nos. 1,329,263, 1,448,550, 1,231,764, 1,427,754, 1,403,475 and 1,465,332; (2) that within the said twenty (20) days defendant file with the Clerk of this Court, and furnish plaintiffs' counsel a 5084
copy, an affidavit executed by an officer of the defendant, setting forth year by year the number of infringing amplifiers which have been manufactured, used, sold, leased or otherwise furnished by the defendant since its incorporation, the number of such amplifiers which are still in use, and the number of such amplifiers which the defendant has in its possession or under its control; (3) that the defendant not sell, lease or otherwise dispose of until further order of this Court any of the said amplifiers which it now has in its possession or under its control. 5085

Mortimer W. Byers,
United States District Judge.

Dated, Oct. 27, 1936.

Approved as to Form:

Darby & Darby,
Counsel for Defendant.

Henry R. Ashton,
Counsel for Plaintiffs.

5086 **Defendant's Petition for Appeal (Three Suits).**

UNITED STATES DISTRICT COURT,

SOUTHERN DISTRICT OF NEW YORK.

WESTERN ELECTRIC COMPANY, INCORPORATED, ELECTRICAL RESEARCH PRODUCTS, INC., and AMERICAN TELEPHONE AND TELEGRAPH COMPANY, Plaintiffs, vs. GENERAL TALKING PICTURES CORPORATION, Defendant.	Equity Nos. 50/175, 50/177, 50/178.

5087

The above named defendant, General Talking Pictures Corporation, conceiving itself aggrieved by the interlocutory decree entered herein on October 28, 1936, does hereby appeal from said decree to the United States Circuit Court of Appeals for the Second Circuit for the reasons specified in the assignment of errors which is
5088 filed herewith; and it prays that this appeal may be allowed and citation granted, directed to the above named plaintiffs, Western Electric Company, Incorporated, Electrical Research Products, Inc., and American Telephone and Telegraph Company, demanding them to appear before the United States Circuit Court of Appeals for the Second Circuit to do and receive what may appertain to justice to be done in the premises; and asks that a transcript of the pleadings, proceedings, testimony, exhibits, and orders, together with a copy of the opinion of this Court filed in this cause upon which said decree was

entered, duly authenticated by the Clerk of the Court, be transmitted to the United States Circuit Court of Appeals for the Second Circuit under the rules and statutes in such cases made and provided.

GENERAL TALKING PICTURES CORPORATION,
By (S) DARBY & DARBY,
Solicitors for Defendant.

Dated, New York, N. Y., November 13, 1936. 5090

Defendant's Order Allowing Appeal (Three Suits).

UNITED STATES DISTRICT COURT,

SOUTHERN DISTRICT OF NEW YORK.

WESTERN ELECTRIC COMPANY, INCORPORATED, ELECTRICAL RESEARCH PRODUCTS, INC., and AMERICAN TELEPHONE AND TELEGRAPH COMPANY, Plaintiffs, vs. GENERAL TALKING PICTURES CORPORATION, Defendant.	Equity Nos. 50/175, 50/177, 50/178.

5091

AND NOW, to wit: this 13th day of November, 1936, upon consideration of the annexed peti-

tion for appeal in the above entitled cause, it is, upon motion by Darby & Darby, solicitors for petitioner,

ORDERED by the Court that the appeal of the defendant, General Talking Pictures Corporation, prayed for therein be and is hereby allowed.

(S) WM. BONDY,
U. S. D. J.

5093

Defendant's Assignment of Errors (Three Suits).

UNITED STATES DISTRICT COURT,

SOUTHERN DISTRICT OF NEW YORK.

5094

WESTERN ELECTRIC COMPANY, INCORPORATED, ELECTRICAL RESEARCH PRODUCTS, INC., and AMERICAN TELEPHONE AND TELEGRAPH COMPANY, Plaintiffs, vs. GENERAL TALKING PICTURES CORPORATION, Defendant.	Equity Nos. 50/175, 50/177, 50/178.

GENERAL TALKING PICTURES CORPORATION, in the above entitled suit, conceiving itself aggrieved by the decree entered therein on the 28th

day of October, 1936, now appearing by its counsel, presents, with the accompanying petition for appeal from said decree, the following assignment of errors:

1. The Trial Court erred in sustaining the bill of complaint and in decreeing an injunction and accounting herein.

2. The Trial Court erred in failing to dismiss the bill herein and in not entering a decree in 5096
favor of the defendant.

3. The Trial Court erred in failing to enter a decree adjudging that the defendant in acquiring equipment in the open market manufactured by a licensee of the plaintiffs under the patents in suit, acquired the right or license under said patents, insofar as that equipment is concerned, to use the equipment for any purpose for which it might be utilized.

4. The Trial Court erred in holding that the 5097
defendant in acquiring equipment in the open market manufactured by a licensee of the plaintiffs under the patents in suit, did not acquire the right or a license under said patents, insofar as that equipment is concerned, to use the equipment for any purpose for which it might be utilized.

5. The Trial Court erred in failing to enter a decree adjudging that a license notice attached to the equipment purchased by the defendant from a manufacturer licensed by the plaintiffs

5098 to manufacture and sell said equipment under the patents in suit restricting the use to which said apparatus may be put, is of no legal effect in restricting the use to which the defendant could put the apparatus so purchased.

6. The Trial Court erred in holding that a license notice attached to the equipment purchased by the defendant from a manufacturer
5099 licensed by the plaintiffs to manufacture and sell said equipment under the patents in suit, restricting the use to which said apparatus may be put, is legally effective in restricting the use to which the defendant could put the apparatus so purchased.

7. The Trial Court erred in failing to enter a decree adjudging that the plaintiffs had ratified or acquiesced in the sale by their licensees of the apparatus and equipment sold to the defendant for the use to which the defendant
5100 intended to put the said apparatus and were estopped from maintaining the suit or receiving the relief prayed for in the bill of complaint herein.

8. The Trial Court erred in holding that the plaintiffs did not ratify or acquiesce in the sale by their licensee of the apparatus and equipment sold to the defendant for the use to which the defendant intended to put the said apparatus, and were not estopped from maintaining the suit or receiving the relief prayed for in the bill of complaint herein.

9. The Trial Court erred in not holding that the plaintiffs had waived all relief by accepting royalties on the allegedly infringing sales to the defendant after the present suit was commenced and retaining such royalties for more than a year with full knowledge of the facts.

10. The Trial Court erred in not holding that by acquiring vacuum tubes in the open market manufactured by plaintiffs' licensees defendant 5102 acquired the right to use the tubes for their intended use in connection with the allegedly infringing amplifiers purchased by defendant from other licensees of plaintiffs whereby defendant was licensed to use the combination of tubes and circuits of each of the patents in suit.

11. The Trial Court erred in entering a decree adjudging the specified claims of the following patents to be valid:

Lowenstein	#1,231,764—claims 1, 2, 4, 5, 6, and 7.	5103
Mathes	1,426,754—claim 8.	
Arnold	1,329,283—claims 7, 10 and 13.	
Arnold	1,403,475—claims 8, 9 and 10.	
Arnold	1,465,332—claims 1, 3, 5, 8, 10 and 11.	
Arnold	1,448,550—claims 1 and 12.	

12. The Trial Court erred in failing to enter a decree adjudging the said claims of the said patents to be invalid as anticipated or wanting in patentable novelty or because of statutory bar.

5104 *Defendant's Statement as to Appeal Bond and Citation.*

13. The Trial Court erred in entering a decree adjudging that the defendant infringed the said claims of the said patents.

WHEREFORE, the defendant prays that the decree of the said District Court of the United States for the Southern District of New York may be corrected and reversed.

5105 GENERAL TALKING PICTURES CORPORATION,
By (s) DARBY & DARBY,
Solicitors for Defendant.

Dated: New York, N. Y., November 13, 1936.

Defendant's Statement as to Supersedeas Bond.

Defendant submitted a supersedeas bond in the sum of $10,000.

5106

Defendant's Statement as to Appeal Bond and Citation.

Defendant submitted an appeal bond in the sum of $250. which was approved and filed, and a citation in the suits was issued on November 13, 1936, and served on November 16, 1936.

Plaintiffs' Petition for Appeal (Equity No. 50-175). 5107

UNITED STATES DISTRICT COURT,

SOUTHERN DISTRICT OF NEW YORK.

WESTERN ELECTRIC COMPANY, INCORPORATED, ELECTRICAL RESEARCH PRODUCTS, INC., and AMERICAN TELEPHONE AND TELEGRAPH COMPANY, Plaintiffs, against GENERAL TALKING PICTURES CORPORATION, Defendant.	In Equity No. 50-175. 5108

The above named plaintiffs, Western Electric Company, Incorporated, Electrical Research Products, Inc., and American Telephone and Telegraph Company, considering themselves aggrieved by the decree made and entered herein
on the 27th day of October, 1936, do hereby 5109
appeal from so much of the said decree as adjudged and decreed claims 1 and 4 of Arnold Letters Patent No. 1,520,994 invalid for the reasons specified in the assignment of errors filed herewith, and they pray that this appeal may be allowed and a citation granted directed to the above named defendant, General Talking Pictures Corporation, commanding it to appear before the United States Circuit Court of Appeals for the Second Circuit, to do and receive what may appertain to justice to be done in the premises, and that a transcript of the record,

5110

proceedings and exhibits on which the said decree was made may be duly authenticated and sent to the United States Circuit Court of Appeals for the Second Circuit.

Western Electric Company, Incorporated, Electrical Research Products, Inc., and American Telephone and Telegraph Company,

By Henry R. Ashton,

5111 Counsel for Plaintiffs-Appellants.

Dated: November 16, 1936.

Allowance of Appeal.

The foregoing appeal is allowed as prayed for and the Clerk of this Court is directed to issue a citation to the said defendant and to certify the record accordingly.

5112

Dated: 11/17/36.

Jno. C. Knox,
United States District Judge.

Service hereof acknowledged this day of November, 1936.

Darby & Darby,
Counsel for Defendant-Appellee.

Plaintiffs' Assignment of Errors (Equity No. 50-175). 5113

UNITED STATES DISTRICT COURT,

SOUTHERN DISTRICT OF NEW YORK.

WESTERN ELECTRIC COMPANY, INCORPORATED, ELECTRICAL RESEARCH PRODUCTS, INC., and AMERICAN TELEPHONE AND TELEGRAPH COMPANY, Plaintiffs, against GENERAL TALKING PICTURES CORPORATION, Defendant.	In Equity No. 50-175.

5114

Now come the plaintiffs in the above entitled case and present with their accompanying petition for appeal from the decree made and entered herein on October 27, 1936, the following assignment of errors: 5115

1. The Court erred in holding claims Nos. 1 and 4 of Arnold Letters Patent No. 1,520,994 invalid and void and in dismissing the bill of complaint as to the said Letters Patent.

2. The Court erred in not holding claims Nos. 1 and 4 of Arnold Patent No. 1,520,994 valid and infringed by the defendant.

3. The Court erred in not ordering an injunction and an accounting with respect to claims

5116 *Plaintiffs' Statement as to Appeal Bond and Citation.*

Nos. 1 and 4 of Arnold Letters Patent No. 1,520,-994.

4. The Court erred in finding that claims Nos. 1 and 4 of Arnold Letters Patent No. 1,520,994 merely involved the selection of a well known means to accomplish a necessary purpose which falls short of indicating the exercise of the inventive faculty.

5117

WESTERN ELECTRIC COMPANY, INCORPORATED, ELECTRICAL RESEARCH PRODUCTS, INC., and AMERICAN TELEPHONE AND TELEGRAPH COMPANY,

By HENRY R. ASHTON,
Counsel for Plaintiffs-Appellants.

Dated: November 16, 1936.

Service hereof acknowledged this 16 day of November, 1936.

5118

SAMUEL E. DARBY,
Counsel for Defendant-Appellee.

Plaintiffs' Statement as to Appeal Bond and Citation.

Plaintiff submitted an appeal bond in the sum of $250. which was approved and filed, and a citation in suit No. 50-175 was issued on November 17, 1936, and served on November 20, 1936.

5119

Stipulated Praecipe.

UNITED STATES DISTRICT COURT,

SOUTHERN DISTRICT OF NEW YORK.

WESTERN ELECTRIC COMPANY, INCORPORATED, ELECTRICAL RESEARCH PRODUCTS, INC., and AMERICAN TELEPHONE AND TELEGRAPH COMPANY, Plaintiffs, vs. GENERAL TALKING PICTURES CORPORATION, Defendant.	In Equity Nos. 50-175, 50-177, 50-178.

5120

IT IS HEREBY STIPULATED AND AGREED, by and between counsel for the respective parties hereto, that the printed record to be transmitted to the Court of Appeals for the Second Circuit, pursuant to the appeals heretofore taken in these cases, shall contain the following: 5121

1. Bill of Complaint in No. 175.
2. Amendment to Bill of Complaint in No. 175.
3. Answer in No. 175.
4. Defendant's Bill of Particulars in No. 175.
5. Stipulation and Order Amending Answer in No. 175.
6. Decree in No. 175.
7. Bill of Complaint in No. 177.
8. Amendment to Bill of Complaint in No. 177.

5122

9. Answer in No. 177.
10. Defendant's Bill of Particulars in No. 177.
11. Stipulation and Order Amending Answer in No. 177.
12. Decree in No. 177.
13. Bill of Complaint in No. 178.
14. Amendment to Bill of Complaint in No. 178.
15. Answer in No. 178.
16. Defendant's Bill of Particulars in No. 178.

5123

17. Stipulation and Order Amending Answer in No. 178.
18. Decree in No. 178.
19. The Opinion, dated Sept. 16, 1936.
20. Stipulation and Order in the three suits that opinion be deemed sufficient findings of fact and conclusions of law.
21. Supersedeas Order in the three suits.
22. Defendant's Petition for Appeal in the three suits.
23. Order Allowing Defendant's Appeals in the three suits.

5124

24. Defendant's Assignment of Errors in the three suits.
25. Statement as follows: "Defendant submitted a supersedeas bond in the sum of $10,000."
26. Statement as follows: "Defendant submitted an Appeal Bond in the sum of $250. which was approved and filed, and a citation in the three suits was issued on Nov. 13, 1936, and served on November 16, 1936."
27. Plaintiffs' Petition and Order Allowing Appeal in No. 175.

28. Plaintiffs' Assignment of Errors in No. 175.

29. Statement: "Plaintiff submitted an appeal bond in the sum of $250. which was approved and filed, and a citation in suit No. 175 was issued on November 17, 1936, and served on November 20, 1936."

30. Statement of the testimony.

31. Exhibits to be reproduced:
Plaintiffs' Exhibits: 1 A to 1 H, 2 to 10,
13 to 15, 17, 19, 20, 24 to 26, 31 to 37, 39 5126
to 66, 73 to 78. (Omit 57 and 58 and 1D.)
Defendant's Exhibits: A to N.

32. The following Exhibits are to be transmitted to the Court of Appeals as Physical Exhibits:
Plaintiffs' Exhibits 11, 12, 16, 18, 21, 22, 23, 27, 28, 30, 38, 67 to 72, 57 and 58.

32A. List of references cited in Patent Office during prosecution of Lowenstein and Mathes patents.

33. This stipulated praecipe.

34. Stipulation and Order approving the state- 5127
ment of evidence.

35. Clerk's Certificate.

(Sgd.) Samuel E. Darby, Jr.,
Counsel for Defendant.

(Sgd.) Henry R. Ashton,
Counsel for Plaintiffs.

Dated: February , 1937.

5128

Stipulation.

UNITED STATES DISTRICT COURT,

SOUTHERN DISTRICT OF NEW YORK.

WESTERN ELECTRIC COMPANY, INCORPORATED, ELECTRICAL RESEARCH PRODUCTS, INC., and AMERICAN TELEPHONE AND TELEGRAPH COMPANY, Plaintiffs-Appellants, vs. GENERAL TALKING PICTURES CORPORATION, Defendant-Appellant.	In Equity Nos. 50-175, 50-177, 50-178.

5129

IT IS HEREBY STIPULATED AND AGREED that the foregoing in three volumes is a true transcript of the record in the above entitled cases, as agreed upon by the parties.

5130 Dated: April , 1937.

HENRY R. ASHTON,
Counsel for Plaintiffs.

DARBY & DARBY,
Counsel for Defendant.

5131

Clerk's Certificate.

United States of America, } ss.:
Southern District of New York,

Western Electric Company, Incorporated, Electrical Research Products, Inc., and American Telephone and Telegraph Company,
Plaintiffs-Appellants,

vs.

General Talking Pictures Corporation,
Defendant-Appellant.

In Equity
Nos. 50-175,
50-177, 5132
50-178.

I, Charles Weiser, Clerk of the District Court of the United States for the Southern District of New York, do hereby certify that the foregoing in three volumes is a correct transcript of the record of the said District Court in the above-entitled cases, as agreed upon by the parties. 5133

In Testimony Whereof, I have caused the seal of the said Court to be hereunto affixed, at the City of New York, in the Southern District of New York, this day of April, 1937.

Charles Weiser,
Clerk.

(Seal)

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[fol. 1712] UNITED STATES CIRCUIT COURT OF APPEALS FOR THE SECOND CIRCUIT

WESTERN ELECTRIC COMPANY, INCORPORATED; ELECTRICAL RESEARCH PRODUCTS, INC., and American Telephone and Telegraph Company, Plaintiffs-Appellees, Appellants,

against

GENERAL TALKING PICTURES CORPORATION, Defendant-Appellant, Appellee.

Before Manton, Swan and A. N. Hand, Circuit Judges

Appeal from the District Court for the Southern District of New York. Suit for infringement of seven patents. Decree for plaintiffs on six patents and for the defendant on one. Both parties appeal. Decree affirmed.

Darby & Darby, Zeiger & Berliner, Solicitors for Defendant; Samuel E. Darby, Jr., Ephraim Berliner, of Counsel.

Merrell E. Clark, Henry R. Ashton, Counsel for Plaintiff; Charles Neave, F. T. Woodward, H. A. Pattison, E. J. Driscoll, of Counsel.

MANTON, Circuit Judge:

Three suits for patent infringement were tried together and will be considered in one opinion. (Western Electric Co. v. General Talking Pictures, 16 Fed. Supp. 293.) They involve the validity of decrees holding valid and infringed the Lowenstein Patent No. 1,231,764 (Claims 1, 2, 4, 5, 6, 7) for a Negative Grid Bias, filed April 24, 1912; Mathes patent No. 1,426,754 for a Grid Biasing Resistance, filed October 23, [fol. 1713] 1916 (Claim 8); Arnold patent No. 1,329,283 (Claims 7, 10, 13) for a Power Circuit, application filed May 28, 1914; Arnold Patent No. 1,403,475 (Claims 8, 9, 10), for Resistance Capacity Coupling, application filed September 3, 1915; Arnold patent No. 1,448,550 (Claims 1, 12), for Definite Input Impedance, original applications filed September 3, 1915 and November 2, 1915; Arnold patent No. 1,465,332 (claims 1, 3, 5, 8, 10, 11) for Common Plate Supply, original application filed September 3, 1915. The Arnold patent No. 1,520,994 (Claims 1 and 4), for Gain Control, original application filed September 3, 1915, was held invalid.

These patents relate to the vacuum tube amplifier. Infringement is not seriously disputed if the patents are valid. The defendant, in addition to the general claim of invalidity of each patent, defends upon the ground that the five Arnold patents are invalid because of public use by one of the plaintiffs, American Telephone & Telegraph Company, for more than two years before the particular applications, upon which the patents were issued, were filed. None of the five patents was in public use more than two years before the original applications were filed and the inventions of but three of them (Nos. 1,329,283; 1,448,550 and 1,520,-994) were in such public use more than two years before the particular applications on which they were issued were filed. Such applications in each instance were copending with the original applications. Another defense is made, based on the claim that because these amplifiers were purchased from the American Transformer Co., a licensee under the patents, although their sales were for private (amateur and experimental) use, infringement is avoided. The sales, however, [fol. 1714] to defendant were specifically for public or business use, that is, reproducing talking motion pictures in theatres for profit. Defendant leased the amplifiers it purchased to theatre owners and operators.

A defense is made that there was an acquiescence by plaintiffs in the infringement which amounts to an estoppel.

The patents relate to combinations of three electrode vacuum tubes, and circuits and circuit elements useful for amplification. Each of the ordinary sounds of speech and music is composed of many different frequencies which must be accurately reproduced. The problem of amplification was to reproduce without distortion the input of the amplifier in its output greatly increased in energy. The patents in suit deal with one or more of the problems of this art of amplification which the patentee solved while the art was still young. The latest of the inventions was made in 1916 before amplification was commercially applied to such uses as radio broadcast transmission and reception, public address systems and talking motion pictures. All inventions, except that of Lowenstein, were made by the inventors employed by the Western Electric Company.

There can be no earnest denial of the usefulness and commercial success of the inventions which were held valid below.

Lowenstein Patent

The Negative Grid Bias patent of Lowenstein solved the problem of distortion in the input circuit of the three-electrode tube, which was due to the flow of current in that circuit. He eliminated distortion producing current by providing means for biasing the grid negatively. We held this [fol. 1715] patent valid and infringed in Western Electric Co. v. Wallerstein, 60 Fed. 2, 723. The same claims 1, 2, 4, 5, 6 and 7 were there involved. The defendant admits that the prior art now relied upon was considered by us in the earlier decision. The arguments against the validity of the Lowenstein patent now appearing were considered there and nothing is added here which warrants our overruling the decision there. We there considered the patents to Von Lieben (No. 1,038,910), Stone (No. 884,110), and DeForest (Nos. 841,347; 879,532; 995,126) and found that they did not anticipate this patent, and we concluded that Lowenstein made a contribution to the art of great merit and this patent was held valid and infringed. Its claims are infringed here.

Mathes Patent

The Grid Biasing Resistance Patent to Mathes provided an improved means of obtaining the negative grid potential of the Lowenstein patent, which improved means had the advantage of eliminating the extra battery (c) employed by Lowenstein. He accomplished this by making the filament heating or "a" battery serve, in combination with a resistance placed in the filament heating circuit, the additional function of biasing the grid. Claim 8 defines the specific and useful series circuit combination of grid biasing resistance, filament heating battery and filament, the grid biasing resistance being included in the same circuit as the filament and filament heating battery.

As prior art the defendant refers to Arnold Patents No. 1,129,942 and No. 1,129,943 and Colpitts Patent No. 1,388,-450. The Arnold patents do not disclose a grid biasing resistance in the filament heating circuit, as claimed in Mathes' [fol. 1716] Claim 8, but employ a separate battery, as Lowenstein did, for providing the desired negative grid potential. But defendant argues that in the Arnold patents the filaments of the three tubes shown are all connected together in series so that all can be heated by the "a" battery, and

says that the resistance (14) corresponds to Mathes' resistance. But that resistance is not in the filament heating circuit of the tube as Mathes' claim 8 provides. The purpose for which the resistance (14) is used in the Arnold patent is solely to act as a coupling between the output circuit of the first tube and the input circuit of the second tube. The effect on the grid of the second tube of the drop in potential across the resistance (14) is wholly erased by the positive potential of the plate battery (13) which is poled positively to the grid of the second tube. The grid of the second tube is not biased negatively by this resistance but is so biased by Lowenstein's battery (11), poled negatively to the grid and included in the circuit for the same purpose as in Lowenstein's patent. The testimony shows that if the Lowenstein battery (11) was not included in the circuit to buck out the effective positive voltage from the plate battery (13), the grid of the tube would be highly positive notwithstanding the presence of the resistance (14). The grid would be at the same high and positive potential as the plate of the preceding tube, to which it would be directly connected were it not for Lowenstein's battery (11). Instead of teaching that Lowenstein's battery can be dispensed with, these Arnold patents teach that it should be used and they do not teach, as Mathes provides, that the filament heating battery can serve the additional function of biasing the [fol. 1717] grid if the biasing resistance is included in the series in the filament heating circuit.

Colpitts discloses a resistance not in the filament heating circuit. The resistance (64) tends to compensate out or eliminate the signal which it is the whole purpose of the amplifier to strengthen. This resistance has a deamplifying effect which makes it objectionable in an amplifier. Defendant has been unable to establish priority of invention. Mathes made a distanct contribution to the art in the particular series arrangement of grid biasing resistance, filament and filament heating source; the invention is held valid.

Arnold Patent No. 1,329,283

This is the Power Circuit Patent issued in 1920 upon an application filed July 30, 1918, which was a continuation of two earlier applications filed May 28, 1914. Arnold discloses in this patent the fundamentals of the tube's operations and how to construct it so as definitely to adapt it to

utilization in circuits and with other circuit elements to give efficient results. He teaches how to produce tubes having the desired characteristics, and how to determine in what circuit arrangement the particular types of tubes should be used to do the work. The invention relates to thermionic amplifiers of the audion type and its object is to provide a structure by which the certain desired characteristic of the amplifier may be secured at will and in an efficient manner. The principles of operation are referred to and four suggestions as to construction are made. They are, (a) to locate the grid as near as possible to the filament for all purposes; (b) space the plate widely from the filament for high voltage output and closely for high current output; (c) use a [fol. 1718] fine mesh grid for high voltage output and a coarse mesh grid for high current output, and (d) for maximum efficiency, to construct the tube so that its internal impedance between the plate and the filament is "equal to the total impedance of the variable current consumption circuit." Thus the internal impedance between the plate and filament of the tubes should equal or match the impedance of the external circuit, including the receiving or translating device to which power is to be supplied. In producing an amplifier with a high current or a large power output, these principles are applied. Such were the defendant's amplifiers. Greater power is required to drive the loud speakers for public address, or motion picture systems than is required for radio or telephone. Without the power amplifier disclosed in this patent, it is said that public address, and talking motion picture systems could not be successfully operated with any loud speaker yet devised.

The claims in suit—Nos. 7, 10 and 13—are each for a novel combination of a power or high current three-electrode vacuum tube of low impedance with a work circuit having low impedance of the same order of magnitude. Claim 7 specifies that the three elements of the tube are so spaced that the impedance of the discharge device (tube) between said anode (plate) and cathode (filament) is of the same order as that of the outgoing (work) circuit. Claim 10 is more specific, stating the filament is placed in immediate proximity to the grid, and that the plate is so spaced from the filament and the grid made of such coarse mesh that the two impedances mentioned above are of the same order. Claim 13 is similar to Claim 7, adding however, "a source of variable electro-motive force in said input circuit."

[fol. 1719] The prior art referred to, the Seibt patent, No. 1,012,456, was not dealing with a vacuum tube which was unknown when Seibt filed his application in 1907. He shows an arc transmitter with a microphone and taught that in such a system a maximum output may be obtained when the resistance of the microphone is equal to the resistance of the rest of the system. This patent has no bearing upon this invention. The other patents referred to, Colpitts No. 1,129,959, and Langmuir No. 1,558,436, do not anticipate.

Defendant relies on Arnold patent No. 1,129,943 and claims that what Arnold disclosed in that patent and did not claim, he abandoned, and cannot reclaim what he has abandoned by his application filed more than three years subsequent to the issuance of the earlier patent. This is contrary to our ruling in Traitel Marble Co. v. Hungerford, 22 Fed. 2, 259. The application for the Arnold patent No. 1,129,943 was filed May 28, 1914, the same day on which the original applications upon which the patent now considered was based.

Each of the three Arnold applications disclosed the invention of the patent in suit and the application on which it issued was copending with the original applications. This Power Circuit Patent has become an important contribution to the art here involved. It has become a device of very practical usefulness. It has organized elements and adapted their relations to the circuit described and constitutes an invention.

[fol. 1720] Arnold Patent No. 1,403,475

This Resistance Capacity Coupling Patent issued January 17, 1922, on an application filed November 11, 1920, is a division of and was copending with Arnold's original Serial No. 48,873, filed September 3, 1915. The invention was employed in the receivers used in radio telephone experiments in 1915. It disclosed a new method of coupling the output circuit of one three-electrode vacuum tube to the input circuit of another, by which what is known as frequency distortion is avoided. This new coupling made it possible for the first tube to pass on to the next all frequencies of the signals equally amplified, without distorting any of them. Another advantage of the coupling is that extremely small as well as large currents or energies are equally effectively passed to the next tube. This is of advantage for talking

motion pictures. In such amplifiers only a very small energy is produced by the photo-electric cell when light, modulated only by variations of density of the talking motion picture films, falls upon the cell. The direct current path of the plate or output circuit of the first tube consists of the space between the plate and the filament, the battery, the choke coil and the resistance which is the coupling resistance. The voltage variation at the top of this resistance corresponds exactly to the signal no matter what the frequency. The grid of the second tube is connected to its filament through the biasing battery and the resistance (29), the function of the latter being to permit the electrons, which would otherwise accumulate on the grid of the second tube and block the operation, to leak off through the resistance. Claims 8, 9 and 10 each specify the resistance and condenser of the [fol. 1721] patent, and claim 10 includes additionally the resistance (29).

The Arnold patent No. 1,129,942 of the prior art does not disclose a resistance capacity coupling amplifier. Defendant claims in fig. 6 the coupling between the first and second tube is a resistance capacity coupling, but it is not. It is an inductance capacity coupling as the defendant's expert admitted, referring to the difference as an essential one. An inductance consisting of a wire-wound iron core, impedes the flow of alternating current, impeding high frequencies more than low, and causing distortion. The object of the patent in suit was to avoid such discrimination. We think this patent valid.

Arnold Patent No. 1,448,550

This Definite Input Impedance Patent issued March 13, 1923, upon an application filed February 3, 1919, was the continuation of two earlier applications filed September 3, 1915, and November 2, 1915. The input circuit of a three-electrode vacuum tube has a very high impedance. When the negative grid bias invention is used, the impedance of the input circuit becomes substantially infinite because no electrons can flow from the filament to an electrode which is negative. A tube to be useful, as from the end of a telephone line or the output side of another vacuum tube, needs connections to its input circuit so as to supply the tube with the signals to be amplified. In the absence of this invention, the action which would occur in imposing the signals on the

input circuit would cause a rebound. The reflection back into the line or into the preceding tube, due to the high [fol. 1722] impedance encountered may produce an echo in the telephone line which the speaker at the far end of the line will hear as an interfering echo of his own voice. And it may disturb the operation of other amplifiers in the line and might result in producing a state of resonance in the transformer at the end of the line upsetting its operation so that it will discriminate as to certain frequencies and may result in a feed back by setting up undesired oscillations which will be fed back into the line or preceding tube and interfere with their operations. These defects were cured by this invention now considered.

Claim 12 differs from Claim 1 only in that it specifies that the impedance is of the order of 500,000 ohms as in defendant's amplifier. Other engineers were engaged in finding a solution of the problem, particularly those associated in the Western Electric Company and failed until Arnold made this invention.

We think this patent is valid and withstands the attack of double patenting claimed. Defendant asserts double patenting by this patent and the subject matter of the Arnold Power Circuit Patent in suit. The claim of invention of the patent in suit is a high impedance connected across the secondary of the input transformer of a three-electrode vacuum tube amplifier. Such invention is not found in any of the claims of the Arnold Power Circuit. For double patenting it must appear that the claims are the same. Traitel Marble Co. v. Hungerford, 22 Fed. 2, 259,262.

Arnold Patent No. 1,465,332

This patent is for a Common Plate Supply. It issued on a divisional application filed August 28, 1920, which was [fol. 1723] based on an application filed September 3, 1915. This invention made it possible for the first time to use a common source of plate current for two or more three-electrode vacuum tube amplifiers without introducing prohibitive distortion. The problem was in using the common source to prevent that source and the connections to it from serving as a path through which the amplified signals in the plate circuit of the subsequent tube or tubes could get back into the circuits of the preceding tube or tubes thereby setting the circuits into a state of oscillation or regenera-

tion. When such feed back occurs, the amplified signals in such tube will flow into the plate circuit of the preceding tube and through that circuit will again be impressed on the input circuit of the tube from which they came; the cycle thus set up will change the tube into a generator of oscillations nullifying the usefulness of an amplifier.

This invention made it possible to use a common plate or direct current supply for a plurality of tubes while preserving the alternating or signal current separateness of the output circuits of the tubes.

Prior to this invention whenever a plurality of vacuum tube amplifiers were used, it was necessary to employ separate sources of plate current for each of the tubes in order to prevent the introduction of prohibitive distortions. By this invention it became possible for the first time to use a common plate supply for all the tubes without distorting the output of the amplifier system.

Arnold patent No. 1,129,942 is referred to as an anticipation. This earlier patent shows a battery for supplying plate current to a plurality of tubes, but it does not disclose [fol. 1724] the arrangement of series inductances and shunt condensers as shown in this patent and which are essential to the best results with a common source of plate current in an amplifier. Without these filter means prohibitive distortion is introduced through the path common to the tubes. Claims in suit 1, 3, 5, 8, 10 and 11 are all infringed.

Arnold Patent No. 1,520,994

This is the Gain Control Patent applied for March 28, 1919, and issued Wecember, 1924; the original application was filed September 3, 1915. The claim for this patent is that it was impossible to control the gain, that is the amount or degree of amplification of a three-electrode vacuum tube amplifier without seriously upsetting the operations of the entire system. This patent is for a variable resistance in the place where the resistance involved in the definite input impedance patent was placed. The purpose of the invention was to effect an easy means of regulating the amount of amplification to be obtained by regulating the length of the resistance, which would be in the grid circuit. The court below properly found that this was applying a potentiometer to the resistance to reach a result which such an instrument would be expected to produce. With knowledge

of the well known use of a potentiometer, it did not require invention to make use of this device. It is therefore unnecessary to consider the patents of the prior art referred to. A This patent is held to be invalid for want of invention.

But it is contended by the defendant that the five Arnold patents are invalid because of public use made by the plain- [fol. 1725] tiff, the American Telephone & Telegraph Co., the patentee or patent owner, more than two years before the particular applications on which these patents issued were filed. There is no proof of public use of the inventions, The Resistance Capacity Coupling Patent or the Common Plate Supply Patent, prior to the filing dates of the applications on which these patents issued. These patents may be excluded from this defense. The other three Arnold patents, July 30, 18 Power Circuit Patent, 2/3/19 Definite Impedance Patent, and 3/28/19 Gain Control Patent, were used in the transcontinental line of the Telephone Company which was opened to the public in January, 1915, the first two issued on continuing applications and the third on a divisional application. There was continuity of prosecution between the original applications and the continuing and divisional applications, and the original applications in each instance fully disclose the invention. In the instance of the Power Circuit Patent, the original application was filed more than a year before the public use relied upon, and the original applications for the other two patents were filed less than a year after the public use.

Defendant's contention seems to be that no patent is valid unless the application on which it issued was filed less than two years subsequent to any public use. It refers us to Westinghouse Elec. & Mfg. Co. v. Jeffrey-DeWitt Insulator Co., 22 Fed. 2, 277 (C. C. A. 2); Crown Cork & Seal Co. v. Ferdinand Gutmann Co., 86 Fed. 2, 698; Webster Elec. Co. v. Splitdorf Elec. Co., 264 U. S. 463, and Chapman v. Wintroath, 252 U. S. 126.

In the Westinghouse case, the patent in suit had issued under a divisional application which was filed more than two years after the defendant had itself commenced the [fol. 1726] sale of the infringing device, whereas here the public use relied upon is that of the patentee or patent owner. It was not an adverse public use or one which was antagonistic to the patentee. The divisional application is normally entitled to the benefit of the original filing date and it is

difficult to see how public use under license from an applicant can amount to laches under which adverse rights may arise. Wirebounds Patent Co. v. Saranac Machine Corp., 37 Fed. 2, 830,841. The Westinghouse, Webster Electric Co. and Chapman cases (supra) involve intervening adverse rights either of the defendant or some third party. In the instant case there is no pretense whatever of any claim to intervening rights, either of defendants' own or of anyone else. The patentee's public use of his own invention after filing his original application does not invalidate the patent issued upon a division made more than two years after such public use.

In the Crown Cork & Seal Co. case (supra), an adverse patent for the same invention had issued to a third party before the divisional application for the patent in suit was applied for. There also the patentee had not only deliberately cancelled the disclosure of the invention from the specifications of his original application, but had also cancelled the claims which were sufficiently broad to cover the invention. The patentee had really abandoned the invention, and we said, "might never have considered the subject worth claiming as an invention" had a patent for the invention not issued to another.

But the defendant claims that the subject matter of the claims in suit of the Arnold patents was not claimed in the original applications. It is true that the particular combina- [fol. 1727] tions of the claims in suit were not specifically claimed but broader combinations were claimed. And in the Crown Cork & Seal Co. case, we said:

"A patentee is not to be held at fault for failure to have divided his claims at an earlier date, merely because he might have, when instead he had elected to prosecute the broader claims of his original application."

We also pointed out a distinction to be made between this case and the Crown Cork & Seal Co. case by saying,

"But in the case at bar for a period of more than two years Warth apparently did not wish to claim the preheating method, having deliberately cancelled the pre-heating specification from his original application and shaped his claims so as to exclude it and his patent having been granted January 6, 1931."

This defense we deem no bar to the Arnold patents.

A separate defense is interposed by defendant contending that the amplifiers charged with infringement were licensed because they were purchased from a licensee. February 1, 1927, the Transformer Company obtained from the Radio Corporation, with the assent of the patentee, a license to manufacture and sell patented amplifiers for private, that is, amateur and experimental, uses only. The defendant purchased these amplifiers from the Transformer Company with knowledge of the restriction but used the patented device commercially. The question presented is whether the restriction is binding upon the appellant as a purchaser from the licensee.

A patentee who, under the patent laws, is granted an exclusive monopoly of use, should be able to reserve and preserve his monopoly over the commercial use of his patented [fol. 1728] invention; in other words, he may altogether exclude others from the commercial field. It is not disputed that under the patent law the patentee may impose binding restrictions upon the licensee which would include the restriction in issue. But it is maintained that upon the sale of the patented article restrictions of any kind are no longer enforcible by authority of the patent laws and that the patentee must seek protection, if any, under ordinary rules of contract. Motion Pictures Co. v. Universal Film Co. (243 U. S. 502) in overruling Henry v. A. B. Dick Co. (224 U. S. 1) held ineffective a restriction on the use of a patented invention to materials not covered by the patent itself. The Carbice Corp. v. American Patents Corp. (283 U. S. 27) reaffirmed this rule stating that the patentee cannot, by such a restriction, monopolize commerce in unpatented materials. The court compared the problem before it with that of restrictions upon resale price which had been nullified in Bauer v. O'Donnell (229 U. S. 1) and in subsequent cases (Straus v. Victor Machine Co., 243 U. S. 490; Boston Store v. Graphone Co., 246 U. S. 8) and termed such restrictions "limitations beyond the legitimate scope of its [the patentee's] monopoly." The holdings of these cases are not necessarily controlling on the point here at issue and could rest on the valid distinction that even under the patent law the monopoly of use, though granted by the statute in unqualified terms, is subject to limitations as to the kind of restrictions which may lawfully be imposed. A policy preventing control of resale prices and an extension of monop-

oly to unpatented materials would have nothing to do with the patentee's expressed desire, known to the purchaser, to [fol. 1729] keep the commercial field within its exclusive dominion.

The Supreme Court has stated obiter that the sale of the patented invention puts it beyond the confines of the patent law (Boston Store case, 246 U. S. 8) where a resale price restriction was held invalid as against a purchaser and again in United States v. General Electric Co. (272 U. S. 476) where such a restriction was upheld against licensee. In the Boston Store case, supra, it was stated that "price-fixing contracts are contrary to general law, void, and not within the remedies of the patent law." Such language suggests that the real reason underlying its holdings, and a restrictive explanation of the doctrine it enunciated so broadly, is, that there is a policy forbidding the remote control of resale prices. Mitchell v. Hawley (83 U. S. 544) which upheld a restriction of use to the original terms of the patent, can be supported. In that case there is a holding that such a restriction is valid against purchasers. In Bloomer v. McQuewan (14 How. 539) referred to by the defendant, the court stated there were no restrictions or conditions imposed and hence the purchasers were in no way limited.

This circuit recognized that the patentee may extend his monopoly beyond a sale by a licensee. General Electric Co. v. Continental Lamp Wks., 280 Fed. 846; Radio Corp. v. Andrea, decided June 7, 1937 (C. C. A. 2). It was beyond the scope of the American Transformer Company's license to sell the amplifiers for the use for which it sold them to defendants. The sale was therefore an infringement and not a licensee's lawful sale.

Another separate defense is interposed because of al- [fol. 1730] leged acquiescence by the plaintiffs in the infringement charged which is said to create an estoppel. Alleged conferences with the plaintiffs' officials, which they deny, are urged upon this question of acquiescence and ratification. The trial judge found against the claim that these conversations resulted in acquiescence or approval of the defendant's infringement.

Royalties were received and it is shown that the Radio Corporation of America refunded the royalties collected with respect to infringing amplifiers within two years after

they received a list showing who were the purchasers from the Transformer Company, and all the defendant's strictures against plaintiffs for receiving royalties for over a year after the suit was filed constitutes neither acquiescence nor ratification. The evidence shows lack of knowledge when royalties were received and it is difficult to see how later royalties can act as either acquiescence or estoppel since the very maintenance of the suit showed defendant that there was no acquiescence on which it could rely. If the royalties had not been returned perhaps it might have had some effect upon the plaintiffs' damages. All refunded royalties were accepted by the Transformer Company. But whether they were refunded or not is immaterial. See, Vulcan Mfg. Co. v. Maytag Co., 73 Fed. 2, 136. The first knowledge the plaintiffs had that the defendant was exceeding its license was in April 1929 and within five months it instituted this suit. This defense is without merit.

Decrees affirmed.

[fol. 1730½] [Endorsed:] United States Circuit Court of Appeals, Second Circuit. Western Electric Co. et al. v. General Talking Pictures. (Copy.) Opinion. Manton, Circuit Judge.

[fol. 1731] United States Circuit Court of Appeals, Second Circuit

At a stated term of the United States Circuit Court of Appeals, in and for the Second Circuit, held at the United States Court House, in the City of New York, on the 2nd day of August, one thousand nine hundred and thirty-seven.

Present: Hon. Martin T. Manton, Hon. Thomas W. Swan, Hon. Augustus N. Hand, Circuit Judges.

50/175

WESTERN ELECTRIC COMPANY et al., Plaintiffs-Appellants,

vs.

GENERAL TALKING PICTURES CORPORATION, Defendant-Appellant

Appeal from the District Court of the United States for the Southern District of New York

This cause came on to be heard on the transcript of record from the District Court of the United States for the Southern District of New York, and was argued by counsel.

On consideration whereof, it is now hereby ordered, adjudged, and decreed that the decree of said District Court be and it hereby is affirmed.

It is further ordered that a mandate issue to the said District Court in accordance with this decree.

Wm. Parkin, Clerk.

[fol. 1732] [Endorsed:] United States Circuit Court of Appeals, Second Circuit. Western Electric Company et al. vs. General Talking Pictures Corpn. (50/175.) Order for mandate. United States Circuit Court of Appeals, Second Circuit. Filed Aug. 2, 1937. William Parkin, Clerk.

[fol. 1733] UNITED STATES CIRCUIT COURT OF APPEALS, SECOND CIRCUIT

At a stated term of the United States Circuit Court of Appeals, in and for the Second Circuit, held at the United States Court House, in the City of New York, on the 2nd day of August, one thousand nine hundred and thirty-seven.

Present: Hon. Martin T. Manton, Hon. Thomas W. Swan, Hon. Augustus N. Hand, Circuit Judges.

50/177

WESTERN ELECTRIC COMPANY et al., Plaintiffs-Appellees,

vs.

GENERAL TALKING PICTURES CORPORATION, Defendant-Appellant

Appeal from the District Court of the United States for the Southern District of New York

This cause came on to be heard on the transcript of record from the District Court of the United States for the Southern District of New York, and was argued by counsel.

On consideration whereof, it is now hereby ordered, adjudged, and decreed that the decree of said District Court be and it hereby is affirmed with costs.

It is further ordered that a mandate issue to the said District Court in accordance with this decree.

Wm. Parkin, Clerk.

[fol. 1734] [Endorsed:] United States Circuit Court of Appeals, Second Circuit. Western Electric Company et al. vs. General Talking Pictures Corpn. 50/177. Order for Mandate. United States Circuit Court of Appeals, Second Circuit. Filed Aug. 2, 1937. William Parkin, Clerk.

[fol. 1735] UNITED STATES CIRCUIT COURT OF APPEALS, SECOND CIRCUIT

At a stated term of the United States Circuit Court of Appeals, in and for the Second Circuit, held at the United States Court House, in the City of New York, on the 2nd day of August, one thousand nine hundred and thirty-seven.

Present: Hon. Martin T. Manton, Hon. Thomas W. Swan, Hon. Augustus N. Hand, Circuit Judges.

50/178

Western Electric Company et al., Plaintiffs-Appellees,

vs.

General Talking Pictures Corporation, Defendant-Appellant

Appeal from the District Court of the United States for the Southern District of New York

This cause came on to be heard on the transcript of record from the District Court of the United States for the Southern District of New York, and was argued by counsel.

On consideration whereof, it is now hereby ordered, adjudged, and decreed that the decree of said District Court be and it hereby is affirmed with costs.

It is further ordered that a mandate issue to the said District Court in accordance with this decree.

Wm. Parkin, Clerk.

[fol. 1736] [Endorsed:] United States Circuit Court of Appeals, Second Circuit. Western Electric Company, et al. vs. General Talking Pictures Corpn. (50/178.) Order for Mandate. United States Circuit Court of Appeals, Second Circuit. Filed Aug. 2, 1937. William Parkin, Clerk.

[fol. 1737] United States of America,
Southern District of New York:

I. William Parkin, Clerk of the United States Circuit Court of Appeals for the Second Circuit, do hereby certify that the foregoing pages, numbered from 1 to 1736, inclusive in 3 volumes, contain a true and complete transcript of the record and proceedings had in said Court, in the case of Western Electric Company et al., Plaintiffs-Appellees, against General Talking Pictures Corporation, Defendant-Appellant, as the same remain of record and on file in my office.

In testimony whereof, I have caused the seal of the said Court to be hereunto affixed, at the City of New York, in the Southern District of New York, in the Second Circuit, this twelfth day of August, in the year of our Lord one thousand nine hundred and thirty-seven, and of the Independence of the said United States the one hundred and sixty-second.

Wm. Parkin, Clerk. By D. E. Roberts, Deputy Clerk.
(Seal United States Circuit Court of Appeals, Second Circuit.)

[fol. 1739] SUPREME COURT OF THE UNITED STATES

ORDER ALLOWING CERTIORARI—Filed October 11, 1937

The petition herein for a writ of certiorari to the United States Circuit Court of Appeals for the Second Circuit is granted, and the case is assigned for hearing immediately following No. 72.

And it is further ordered that the duly certified copy of the transcript of the proceedings below which accompanied the petition shall be treated as though filed in response to such writ.

Mr. Justice Roberts took no part in the consideration and decision of this application.

Mr. Justice Black took no part in the consideration and decision of this application.

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